FEDERAL AVIATION REGULATIONS

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION—WASHINGTON, DC

CHANGE 2 — EFFECTIVE: NOVEMBER 2, 1994

Part 27—Airworthiness Standards: Normal Category Rotorcraft

This change incorporates Amendment 27–30, Airworthiness Standards; Crash Resistant Fuel Systems in Normal and Transport Category Rotorcraft, adopted September 26, 1994. This amendment adds two new sections—§§ 27.952 and 27.967—and revises §§ 27.561, 27.963, 27.973, and 27.975.

Bold brackets enclose the most recently changed or added material in these particular sections. The amendment number and effective date of new material appear in bold brackets at the end of each affected section.

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Amendment 27–30

Airworthiness Standards; Crash Resistant Fuel Systems in Normal and Transport Category Rotorcraft

Adopted: September 26, 1994 **Effective: November 2, 1994**

(Published in 59 FR 50380, October 3, 1994)

SUMMARY: These amendments add comprehensive crash resistant fuel system design and test criteria to the airworthiness standards for normal and transport category rotorcraft. Application of these standards will minimize fuel spillage near ignition sources and potential ignition sources and, therefore, will improve the evacuation time needed for crew and passengers to escape a post-crash fire (PCF). Implementation of these amendments will minimize the PCF hazard saving lives and substantially reducing the severity of physiological injuries sustained from PCF's in otherwise survivable accidents.

FOR FURTHER INFORMATION CONTACT: Mr. Mike Mathias, Regulations Group, (ASW–111), Rotorcraft Directorate, Aircraft Certification Office, FAA, Fort Worth, Texas 76193–0111; telephone (817) 624–5123.

SUPPLEMENTARY INFORMATION:

Background

These amendments are based on a Notice of Proposed Rulemaking (NPRM) No. 90–24, issued September 27, 1990 (55 FR 41000, October 5, 1990). A correction to the NPRM was published on December 11, 1990 (55 FR 50931).

Post-crash fires (PCF's) are the primary cause of fatalities and injuries in otherwise survivable impacts resulting from rotorcraft accidents. It is estimated that 5 percent of the occupants in survivable rotorcraft accidents are killed or injured by PCF's annually. These types of fatalities and traumatic injuries will be substantially reduced by the implementation of the design and test criteria of this amendment. Nearly all PCF's are caused by crash-induced fuel leaks that quickly come in contact with ignition sources during or after impact. The fuel containment and hazard elimination provisions contained in this amendment will, in the majority of cases, give occupants the time necessary to escape a survivable crash before a post-crash fire (PCF) could become life threatening. A crash resistant fuel system (CRFS) would not be expected to prevent all fires; however, a CRFS would, in the majority of survivable accidents, either prevent a PCF or delay the massive fire, or fireball, long enough to allow the occupants to escape. These standards have been validated by military safety statistics as significantly minimizing the PCF hazard and its associated fatalities and injuries.

Discussion of Comments

General

Thirteen commenters, including representatives from small and large U.S. helicopter manufacturers, foreign airworthiness authorities, and foreign helicopter manufacturers, commented on the NPRM. All commenters agree with the FAA that CRFS installations will improve occupant survivability in parts 27 and 29 rotorcraft.

The majority of commenters fully support all of the proposals. No commenter opposes adoption of the proposed amendments. One commenter proposes adoption of more stringent standards, and several commenters offer other counterproposals and recommendations for specific proposals.

General comments on the proposals

Unless specifically noted otherwise, the comments and responses apply to both proposed §§ 27.952 and 29.952, since the requirements in both are identical.

The use of the term "flammable fluid"

Flammable fluids other than fuel should not be included in the amendments, since all on-board light and heavy oil systems are affected. Accordingly, the commenter proposes that "flammable fluid" be changed to "fuel." The FAA agrees with this comment, and appropriate changes have been made.

Accuracy of the economic analysis

One commenter questions the accuracy of the economic analysis but offers no specific recommendations or corrections. The FAA has reevaluated the analysis and found no changes were necessary based on this comment.

Rigidity of the proposals

A commenter states that the proposed amendments are "too rigid" in their approach and limit the designers' choices. The FAA disagrees. Although the 50-foot drop height and certain strength requirements are specific, these and most of the other requirements do not mandate specific designs. Objective rules allow flexibility in showing compliance. An example of this flexibility is that bladders are not mandated; the rule specifies only freedom from leakage after impact. The amendments are intended to be as flexible as possible to allow design innovation while at the same time requiring a specific safety standard for a CRFS.

Level of detail in the proposals

A commenter states that the amendments include some very detailed requirements that are more appropriate for a Technical Standard Order (TSO). The FAA agrees that some of the details proposed for paragraphs 27.952(e) and (f) and 29.952(e) and (f) should not be regulatory requirements, are more appropriate for an advisory circular, and should not be part of the proposed standard. Therefore, those details have been removed and placed in the draft advisory material. However, the FAA disagrees with the commenter that the level of detail either in the proposals or in the advisory material would necessitate a CRFS TSO.

The standardized approach of the proposals

A commenter believes that the standardized design and test approach of these amendments to CRFS certification, while acceptable, is not as valid as the establishment of individual design criteria on a case-by-case basis followed by a design review and a test program. However, the commenter offered no specific data or case histories to substantiate this position. Since all past successful civil and military experience has been with a standardized design and test approach, the FAA finds no historical or technical basis to support the commenter. Moreover, the FAA has determined that a standardized design and test approach, when properly applied, still allows for adequate use of individual design features that meet the specific safety standards.

Military standards

A commenter expresses concern that the proposals are less stringent than the corresponding military standard because of perceived differences in the military and civil environments. The commenter is especially concerned that fuel tank bladders are not mandated. The commenter proposes verbatim adoption of the military standards. The FAA disagrees. Based on independent studies, the General Aviation Safety Panel (GASP) committee recommendations, and past civil CRFS service experience, the FAA has determined that the proposals, while less stringent than the military standard, provide an equivalent level of safety considering the differences (such as violent atypical flight maneuvers, landing maneuvers, and gunfire hazards) in the civil and military environments. While it is anticipated that most successful fuel cell designs will involve the use of bladders, bladderless rigid designs (that provide the same level of safety as designs with bladders) may be approved under the new standard.

Comment concerning performance criteria specification

One commenter applauds the fact that the proposal specified performance standards (i.e., a minimum level of safety) in lieu of unnecessarily mandating certain specific design features such as flexible liners.

Comments on specific proposals.

Comments on § 27.561(d)

A commenter questions the need for the specification of load factors in proposed § 27.561(d), since similar load factors are specified in proposed § 27.952(b)(3). The FAA has determined that load factors are needed in both §§ 27.561(d) and 27.952(b)(3). Section 27.561(d) applies to fuselage structure, and § 27.952(b)(3) applies to fuel tanks. Although the load factors are identical, they are specified for different parts of the rotorcraft.

Another commenter correctly states that the load factors are clearly specified for fuel cells by their location on the rotorcraft but asks which load factors are to be used for other major fuel system components.

The load factors used for each fuel cell location should be used for fuel cell components of significant mass in the same locations. Therefore, this amendment is adopted as proposed.

Comments on §§ 27.952(a) and 29.952(a)

A commenter states that identification of a critical fuel tank (if such exists) should not be allowed in certification. The FAA does not agree. The use of critical conditions, systems, etc., is a well-established technique for substantiating similar design features. Therefore, these amendments are adopted as proposed.

Comments on §§ 27.952(a)(1) and 29.952(a)(1)

All commenters support the proposed drop test, and most commenters favor the 50-foot drop height. However, two commenters propose a reduction in the drop height for a bare fuel cell from 50 to 25 feet. Another commenter proposed a reduction in drop height of a fuel cell test article configuration (i.e., a fuel cell installed in its representative airframe structure) from 50 to 15 feet. Another commenter contends that since the military fuel cell drop test (and nearly 20 years of associated, successful safety experience) is at a 65-foot drop height, the proposed drop height should be 65 feet, not 50 feet. The proposed 50-foot drop height is based, in part, on an analysis of nearly 20 years of combined military and civilian design and operational data. (The 15-foot reduction in drop height from the military standard to the proposed civil standard equates their level of safety because of the elimination of the additional risks associated with the military environment.) A significant part of this 20 years of data is based on approximately 1,500 civil rotorcraft that have been certificated (on a voluntary, nonhazard basis) to design standards (including a 50-foot drop test) analogous to these proposals. This 20 years of data and experience (from both the military and voluntary civil unit installations) have resulted in a good operational safety record. This good safety record indicates that fuel tank installations designed to these proposals (including the practical standard of a 50-foot drop height) successfully minimize the post-crash fire hazard. Therefore, no change to the 50-foot drop height is warranted.

Another commenter proposes deletion of the requirement to drop the fuel cell in its surrounding structure. The same commenter asks if the bare tank drop test will follow the procedure of MIL-T-27422B when the surrounding structure is free of projections or design features likely to contribute to tank ruptures. Another commenter states that the requirement to drop a representative structure should be fully defined. The same commenter states that no mention is made of production drop test requirements that would be made necessary by postproduction design changes to either the fuel system or its surrounding structure. The FAA considers these suggested changes unnecessary because (under part 21) a design review (precipitated by a proposed design modification that affects the fuel cell-airframe interface) would automatically require a review of the interface with regard to these proposed standards. If that design review shows the surrounding structure is free of projections and hazards, the fuel cell may be dropped alone. Additionally, MIL-T-274228 procedures may be used, except that the drop height is reduced to 50 feet. Further, major post certification design changes, such as major changes to the fuel system cells or their locations, automatically require recertification in accordance with FAR 21.93(a). Therefore, the amendments are adopted as proposed.

Comments on §§ 27.952(a)(3) and 29.952(a)(3)

A commenter notes that the proposed drop test criteria require that the fuel cell test article be filled 80 percent with water with no mention of the contents of the other 20 percent. The commenter states that this is different from part 23 Notice No. 85-7A (55 FR 7280, February 28, 1990) in that the proposed rotorcraft amendments do not require the air to be removed from the fuel cell prior to the drop test. The commenter suggests that the best method of compensating for the difference between the density of fuel and water is to leave the tank 100 percent full of fuel and adjust the drop height to a lower value.

The FAA notes that the drop test criteria proposed in Notice 90-24 are the same as those proposed in part 23 Notice 85-7A and the same as those used to comply with MIL-T-27422B. There are standard, acceptable methods of configuring (i.e., properly removing the air from) a soft flexible fuel cell, and there are standard, acceptable methods of configuring (i.e., properly removing the air from) the vents on a rigid fuel cell. The air removal methods intended by these proposals are the same as those used to comply with MIL-T-27422B and are accepted, industry practice. It is impracticable to remove a significant amount of air from many rigid fuel cell designs by pulling a vacuum without either inducing unacceptable stresses or causing structural failure. Extreme vacuum conditions inside fuel tanks do not exist in practice. However, natural venting (involving partial vacuums) exists for rigid tanks in a pre-crash, falling condition. A natural partial vacuum condition is intended to be duplicated for rigid tanks by allowing normal vent function during the drop test. Flexible fuel cells will have the air removed by hand (i.e., by pushing out the air and resealing the bag) prior to the drop as is currently practiced by the industry.

The method chosen to compensate for the density of water versus that of fuel (i.e., 80 percent full of water) is a standard method. It is used successfully by the civil rotorcraft industry. The commenter's alternate method of reducing the drop height has some merit but is not supported by current, known data.

Therefore, these amendments are adopted as proposed.

Comments on §§ 27.952(a)(4) and 29.952(a)(4)

A commenter notes that the amendments differ from MIL–T–27422B, in that the amendments require that the tank be dropped in its surrounding structure, unless it is clearly shown that the structure is free from projections and other such hazards. The commenter suggests that the FAA not adopt the requirement to drop the tank in the surrounding structure. The FAA disagrees. The FAA concluded that in the interests of safety the tank should be dropped in its surrounding structure. Only when all projections and-other puncture hazards have been minimized by design will dropping a bare fuel cell suffice to show compliance. The FAA's approach improves on the MIL–T–27422B criteria in that an FAA-approved, documented certification design review will be required to minimize the surrounding airframe projections and other puncture hazards prior to a bare tank drop test. Therefore, the amendments are adopted as proposed.

Comments on §§ 27.952(b) and 29.952(b)

A commenter states that the load factors proposed in these sections are redundant to those contained in structural §§ 27.561 and 29.561(d), that no procedures to conduct these tests have been defined, and that the cost of this type of testing is not addressed. Two other commenters question the need for specification of separate load factors by rotorcraft zone (i.e., location) for fuel cells that exceed the standard airframe load factors. The FAA disagrees that the proposed load factors are redundant. They are for fuel cells and major mass items in the fuel system only. The load factors are to be used in standard structural analysis to structurally design the fuel cells, other major fuel system mass items, and their attachments. No special tests, other than the required structural substantiation tests are intended. No costs have been added since the required structural analysis and test programs are already conducted during certification for these components to the current load factors The separate load factor specification by zone is necessary to provide proper crash resistance for occupant safety and PCF prevention for fuel system components located in three selected zones of the rotorcraft. They also provide the designer with specific criteria (i.e., load factors) for proper static analysis of fuel system components in these specific zones. The load factors proposed by §§ 27.952(b) and 29.952(b) are for fuel system components only; whereas, the load factors of current § 29.561(d) are for the airframe only. However, load factors for fuel system components and airframe components are compatible.

Therefore, the amendments are adopted as proposed.

Comments on §§ 27.952(b)(2) and 29.952(b)(2)

A commenter suggests that the words ". . . that if loosened could injure an occupant in an emergency landing. . . ." be removed from §§ 27.952(b)(2) and 29.952(b)(2). The commenter believes removal to be necessary because this phrase is intended to minimize a "mechanical" ballistic hazard from fuel system components and not a PCF hazard. The amendments, in the commenter's view, are only intended to minimize a PCF. The commenter's presumption is incorrect. The amendments are intended to provide a CRFS. This includes preventing impact-induced, ballistic hazards to fuel system components as well as PCF hazards. Therefore, the amendments are adopted as proposed.

Comments on §§ 27.952(c) and 29.952(c)

A commenter believes that the proposed amendments mandate self-sealing breakaway couplings and suggests that the amendments be revised to include the words "Where hazardous relative motion of fuel system components is likely to exist during a crash, breakaway self-sealing couplings shall be required." Another commenter suggests that no alternate, equivalent designs to breakaway fuel fittings be allowed by the amendments. A third commenter points out that there is no mention of any pull-out strength requirements for fuel tank fittings as stated in MIL–T–27422B. The amendments already express the intent of the wording suggested by the first commenter concerning hazardous relative motion. Further, the FAA does not agree with the second comment that alternate, equivalent designs to breakaway fuel fittings should not be allowed, since several proven, alternate, equivalent designs have already been approved. Thus, alternate, equivalent designs for breakaway fuel fittings are acceptable. In response to the third commenter, fitting strength and hose pull-out strength requirements of MIL–T–27422B are industry practice and are acceptable as one means of compliance. Therefore, the amendments are adopted as proposed.

Comments on §§ 27.952(c)(1)(iii) and 29.952(c)(1)(iii)

A commenter suggests that §§ 27.952(c)(1)(iii) and 29.952(c)(1)(iii) be changed to specify leakage as one method of detecting an unlocked or otherwise faulty breakaway coupling. The FAA agrees that leakage is one method of detecting an unlocked coupling but finds that the proposed wording of "design provisions to visually ascertain" adequately covers consideration of leakage as a means to verify locking of the couplings. Therefore, the amendments are adopted as proposed.

Comments on §§ 27.952(c)(1)(v) and 29.952(c)(1)(v)

A commenter suggests that §§ 27.952(c)(1)(v) and 29.952(c)(1)(v) be changed to allow "fuel seepage" after a breakaway coupling has performed its intended function. The FAA agrees with the intent of the comment but has determined that this kind of detail is more appropriate in advisory guidance material. It is intended that industry practice, which allows loss of entrapped fuel (up to 8 ounces) and fuel seepage (up to 5 drops per minute), be acceptable after the valve has functioned. Therefore, the amendments are adopted as proposed.

Comments on §§ 27.952(d) and 29.952(d)

A commenter suggests adding a sentence between the second and third sentences of §§ 27.952(d) and 29.952(d) as follows: "For tanks using a flexible tank or flexible liner, all filler caps and tank fittings attached to structure in locations of anticipated structural deformation must be frangibly attached such that the tank fittings and filler caps stay with the fuel tank to preclude tank ruptures after the frangible separation." The FAA agrees with the intent of this comment but finds that no change is necessary in the final rule. The FAA understands the commenter is suggesting that compliance methodology rather than objective substance be included in the rule. Therefore, the amendments are adopted as proposed.

Comments on §§ 27.952(d)(1) and 29.952(d)(1)

A commenter suggests that the FAA remove the second sentence from §§ 27.952(d)(1) and 29.952(d)(1), which reads as follows: "To prevent inadvertent separation or deformation, the load must be 10 times the normal service loads at the frangible or deformable attachment location." The FAA recognizes the large variance in industry design practice in calculating this particular ratio and in setting its specific value. Accordingly, the FAA agrees with the commenter, and the sentence is removed from the final rule. Therefore, these amendments are adopted as revised.

Comments on §§ 27.952(e)(1) and 29.952(e)(1)

A commenter states that the proposed §§ 27.952(e)(1) and 29.952(e)(1) criteria largely repeat existing criteria. The commenter provides several specific examples of the perceived repetition. Another commenter asks why airframe mounted fuel filters are not acceptable in the engine compartment (i.e., fire zone) if engine mounted filters are acceptable. The FAA maintains that the proposed sections relate to a post-crash configured rotorcraft, that is radically different in terms of ignition sources, fuel leaks, and geometry than a pre-crash configured rotorcraft even though similarities may exist. Prior to these proposed amendments, parts 27 and 29 applied only to pre-crash (or flight) configured rotorcraft. Also, the proposed sections refer to the entire rotorcraft, not just specific zones, such as the pre-crash configured exhaust system regulations that were cited by the commenter in a particular example. However, because of this and other related comments, the FAA has decided to simplify the final rule by deleting the proposed subsections relating to compliance methodology and moving the term "occupiable areas" from proposed paragraphs e(4) to revised paragraphs (e).

With respect to the comment concerning the use of airframe mounted fuel filters, the FAA agrees that airframe mounted fuel filters, as well as engine mounted fuel filters inside the engine fire zone, are acceptable. Therefore, §§ 27.952(e) and 29.952(e) are adopted as revised; and §§ 27.952(e)(1), (e)(2), (e)(3), (e)(4); 29.952(e)(1), (e)(2), (e)(3) and (e)(4) are deleted.

Comments on § 27.952(e)(4) and 29.952(e)(4)

A commenter states that the existing rules are adequate to ensure sufficient PCF protection for fuel tanks located near occupiable areas. Therefore, from a practical view, sufficient separation cannot be economically achieved to the extent that it would have a significant impact on preventing a PCF. Thus, the commenter suggests that §§ 27.952(e)(4) and 29.952(e)(4) be removed. In contrast, the FAA believes that it is practical to enhance PCF safety through design changes under proposed §§ 27.952(e)(4) and 29.952(e)(4). For example, moving a fuel cell an additional ¼ or more inches aft of an occupied volume (within the maximum practicable extent of a given design envelope) could avoid a major, occupant-drenching, post-crash fuel spill (and potential PCF). This could be accomplished by simply adding ¼ or more inches of crushable, energy absorbing airframe distance between the occupied volume and the fuel cell. Such a design decision would not need to be considered under the current standards. Under these proposals it would have to be considered. As stated previously, §§ 27.952(e)(4) and 29.952(e)(4) have been removed in order to simplify the final rule by deleting the compliance methodology. However, the requirement for separation of fuel tanks from occupiable areas is adopted in §§ 27.952(e) and 29.952(e).

Comments on §§ 27.952(e) and 29.952(e)(5)

Three commenters correctly observe that §§ 27.952(e)(5) and 29.952(e)(5) contained the incorrect reference, ". . . (as defined by paragraph (b) of this section). . . ." The FAA agrees. As stated previously, §§ 27.952(e)(5) and 29.952(e)(5) have been removed in order to simplify the final rule by deleting the compliance methodology.

Comments on §§ 27.952(e)(6) and 29.952(e)(6)

A commenter states that, under his interpretation, proposed §§ 27.952(e)(6) and 29.952(e)(6) would require firewalls to retain their sealing ability under the load factors of §§ 27.952(b)(1) and 29.952(b)(1). The commenter believes that all large mass items, such as engines and cowlings, in the vicinity of the firewall would have to be restrained to prevent impact-induced firewall ruptures (i.e., preserve postimpact sealing ability). The commenter further believes that, based on other common design requirements such as fuel line penetrations of firewalls, the proposed amendment is impractical. Another commenter concurs with the proposed firewall survivable impact sealing retention requirement, but is concerned that a direct application of the proposed §§ 27.952(b)(1) and 29.952(b)(1) load factors would produce a stiff, heavy firewall that, while able to retain sealing capability, would be heavy, uneconomical, and not have the intended crash-resistant design features.

The commenters misinterpreted the intent of proposed §§ 27.952(e)(6) and 29.952(e)(6). These proposals are based on similar MIL–STD–1290 requirements that have been used in design for many years. The FAA does not intend that a firewall designed to the load factors of §§ 27.952(b)(1) and 29.952(b)(1) would retain its complete sealing ability under all post-crash threats. Thus, some leakage around typical vent and line penetrations and other small post-crash penetrations of the firewall in a survivable impact are acceptable. Unless an obvious, catastrophic hazard would be created in a survivable impact by atypical design features, restraint of the engines and cowling to prevent impact-induced firewall rupture was not intended. The FAA intends that the firewall retain its sealing ability in a survivable impact. The most significant problem addressed during the firewall design is deformation of the firewall induced by fuselage deformations under crash conditions.

Concerning the second comment, the FAA does not agree that the proposed requirement will result in stiff, heavy firewalls. The requirement can be met by a firewall of a low stiffness, ductile design that can withstand the maximum vertical, lateral, and horizontal crushing displacements that are estimated to occur in a survivable impact. A low stiffness, ductile design can efficiently accommodate crash-induced deformations without shearing fuel or electrical lines and without rupturing or otherwise losing its gross sealing ability (i.e., creating a major ignition source or fire path). A displacement based firewall certification test should be conducted that shows that it is capable of performing its intended gross sealing function in a survivable impact. As stated previously, in order to simplify the final rule by deleting the compliance methodology, new §§ 27.952(e) and 29.952(e) are adopted as revised, and proposed §§ 27.952(e)(6) and 29.952(e)(6) are removed.

Comments on § 27.952(e)(1)(iv) and 29.952(e)(1)(iv)

A commenter suggests that §§ 27.952(e)(1)(iv) and 29.952(e)(1)(iv) be modified to add the phrase ". . . if it can be considered an ignition source," to the end of the last sentence. The commenter correctly states that not all hot surfaces should be considered as ignition sources. The FAA agrees. As stated previously, §§ 27.952(e)(1)(iv) and 29.952(e)(1)(iv) have been removed; new §§ 27.952(e) and 29.952(e) adequately incorporate the substance of this comment.

Comments on § 27.952(e)(1)(v)

A commenter notes that the word "not" was omitted between "must" and "be" in the second sentence of §§ 27.952(e)(1)(v). The FAA agrees. The error was discovered after publication of the proposed rule, and a correction was published in the *Federal Register* on December 11, 1990 (55 FR 50931).

Comments on § 27.952(f) and 29.952(f)

A commenter recommends placing the detailed design criteria proposed by §§ 27.952(f) and 29.952(f) in an advisory circular retaining only a shortened lead-in version of §§ 27.952(f) and 29.952(f). Another commenter believes that §§ 27.952(f) and 29.952(f), while acceptable in principle, duplicate many current FAR requirements and several other sections of 27.952 and 29.952. The commenter cited several examples of perceived duplication. The FAA agrees with the first commenter's proposal to place detailed design criteria in the advisory circular material. Therefore, proposed §§ 27.952(f)(1) through 27.952(f)(9) and 29.952(f)(1) through 29.952(f)(9) are removed. Sections 27.952(f) and 29.952(f) are revised to replace the proposed, detailed design criteria specified after the phrase "as follows:" with a less detailed design criteria indicated by the phrase, ". . . to be crash resistant. . . ." Therefore, these amendments are adopted as revised. Additionally, this revision answers the second commenter's perceived duplicity concerns.

Another commenter notes that the word "long" used in line 4 of § 29.952(f)(5) should be "along". The FAA agrees but no correction is necessary since this proposed paragraph was removed.

Comments on §§ 27.952(g) and 29.952(g)

A commenter suggests that requirements for impact and tear resistance be included in the amendments. The commenter correctly notes that the GASP report recommends specific impact and tear resistance values for civil rotorcraft based on MIL–T–27422B requirements. The FAA agrees with the comment in general but notes that proposed §§ 27.952(g) and 29.952(g) objectively requires that crash-resistant fuel cells be tear and impact resistant. Further, it is intended that paragraphs 4.6.5.1 through 4.6.5.5 of MIL–T–27422B (modified for the civil environment) may be used to provide one acceptable method of properly assessing impact and tear resistance. Therefore, the amendments are adopted as proposed.

Comments on §§ 27.952(h) and 29.952(h)

Two commenters state that §§ 27.952(h) and 29.952(h) and (b) are redundant. The FAA agrees. Therefore, proposed §§ 27.952(h) and 29.952(h) are deleted.

Comments on §§ 27.975(b) and 29.975(a)(7)

A commenter states full support for §§ 27.975(b) and 29.975(a)(7), which propose that the venting system be designed to minimize spillage of fuel through the vents to an ignition source in the event of a rollover. However, the comment suggests deletion of the phrase ". . . is shown to be extremely improbable . . ." because, in his view, in practical terms, it would be impossible for an applicant to demonstrate such a low probability. The FAA agrees. The current term "extremely remote" rather than "extremely improbable" was intended. The FAA has determined that "extremely remote" is the correct term. The amendments are adopted as proposed except for replacing the word "improbable" with the word " remote."

Regulatory Evaluation Summary

Executive Order 12866 dated September 30, 1993, directs Federal agencies to promulgate new regulations and maintain current regulations only if they are required by law, are necessary to interpret the law, or are made necessary by a "compelling public need." The order also requires that agencies assess all costs and benefits of available regulatory alternatives and select the alternative that maximizes the net benefits and imposes the least burden on society.

Additionally, the order requires agencies to submit a list of all rules, except those specifically exempted by the Office of Information and Regulatory Affairs (OIRA) because they respond to emergency situations or other narrowly defined exigencies, to determine if the rules constitute "significant regulatory action." "Significant regulatory action" means an action that is likely to result in a rule that may (1) have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or state, local, or tribal governments or communities; (2) create a serious inconsistency or otherwise interfere with an action taken or planned by another agency; (3) materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or (4) raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive Order. "Significant regulatory action" is submitted to centralized regulatory review by OIRA.

OIRA and the FAA have determined that this rule is not "a significant regulatory action." However, a cost-benefit analysis, including evaluation of cost-reducing alternatives to this rule has been prepared. This analysis also contains the regulatory flexibility determination required by the Regulatory Flexibility Act and a Trade Impact Assessment. If more detailed economic information is desired, the reader may refer to the full evaluation contained in the docket.

Benefits

Studies have shown that significant PCF hazards exist in rotorcraft operations. In a study of rotorcraft crashworthiness dynamics, the FAA found that burn fatalities and injuries account for about 14 percent of rotorcraft accident casualties and occur in about 20 percent of the accidents in which there are injuries. In a study comparing rotorcraft equipped with and without a CRFS, the U.S. Army found that average thermal casualty costs per survivable accident were 95.4 percent lower in CRFS-equipped rotorcraft, and that 50 percent of all rotorcraft accidents with a PCF are survivable prior to the onset of fire. An FAA review of NTSB rotorcraft accident data from 1983 through 1987 shows that 295 accidents occurred that involved a crash landing or collision with an object resulting in fatalities, serious injuries, or combinations of fatalities and injuries. Sixty-three of these accidents involved a PCF, in which about 77 percent of the occupants were fatally injured, as compared to 42 percent of the occupants in accidents not involving a PCF.

In the 63 accidents involving a PCF, there were 113 fatalities, 27 serious injuries, 5 minor injuries, and one noninjury. The FAA estimates that the use of CRFS's would have altered these casualty distributions to approximately the following: 83 fatalities, 31 serious injuries, 24 minor injuries, and 8 noninjuries—a difference of 30 fewer fatalities with some of the fatalities being reduced to serious injuries (4) and minor injuries (19).

In order to provide the public and government officials with a benchmark comparison of the expected safety benefits of rulemaking actions with estimated costs over an extended period of time, the FAA currently uses a minimum value of $1.5 million to statistically represent an avoided fatality. Serious injuries are estimated to have an average cost of $640,000, and minor injuries are estimated to have an average cost of $2,300. Applying these values to the calculated differences yields benefits of about $42 million [(30 fewer fatalities × $1.5 million) – (4 more serious injuries × $640,000) – (19 more minor injuries × 2,300)]. The average benefit per accident involving a PCF is approximately $670,000. Accounting for parts 27 and 29 separately, the average benefits are approximately $464,000 per part 27 rotorcraft accident involving a PCF and approximately $1,638,000 per part 29 rotorcraft accident involving a PCF.

During the 5-year study period, an average of 5,450 part 27 rotorcraft and an average of 1,150 part 29 rotorcraft were in operation in the United States. During this period, the annual probability of a part 27 rotorcraft being involved in a serious survivable accident with a PCF is estimated to be 1.908×10^{-3} ((52 accidents / 5,450 part 27 rotorcraft) / 5 years). The corresponding probability for part 29 rotorcraft is 1.913×10^{-3} ((11 accidents / 1,150 part 29 rotorcraft) / 5 years). Multiplying these probabilities by the estimated benefits per accident with a PCF yields annual benefits of $885 per part 27 rotorcraft and $3,134 per part 29 rotorcraft. Assuming 15-year operating lives, these benefits when discounted equate to $3,103 per part 27 rotorcraft and $10,985 per part 29 rotorcraft.

Costs

This rule will increase costs for both rotorcraft manufacturers and operators. Manufacturers will incur increased development, certification, and production costs; and operators (in addition to absorbing these costs in higher rotorcraft acquisition costs) will incur increased operating costs due to the additional weight of the fuel system.

The FAA estimates the development and certification costs per new rotorcraft certification will be $36,000. Most of these costs are for testing, analysis, and documentation. The primary testing required by the rule is a test of each fuel tank to show no loss of fuel under specified crash conditions. This can be accomplished by a simple, inexpensive drop test.

There will be increased production costs associated with fuel tanks, fittings, and flexible fuel lines. The incremental cost of a fuel tank meeting the requirements of the rule is estimated to be $30 per gallon of tank capacity. Part 27 rotorcraft are assumed to have 50-gallon tanks that will cost $1,500 more as a result of this rule; part 29 rotorcraft are assumed to have 200-gallon tanks costing $6,000 more. The FAA estimates that the cost per frangible, self-sealing fitting is $60; that a typical part 27 rotorcraft will require 8 fittings, totaling $480; and that a typical part 29 rotorcraft will require 10 fittings, totaling $600. Flexible fuel line sections are expected to add about $100 to the cost of a fuel system for a part 27 rotorcraft and about $150 for a part 29 rotorcraft. The estimated total incremental production costs are $2,080 per part 27 rotorcraft and $6,750 per part 29 rotorcraft.

The FAA estimates that the rule will increase the weight of a part 27 rotorcraft by 9.5 pounds and a part 29 rotorcraft by 33 pounds, and that each extra pound of weight increases average annual fuel consumption by 3.8 gallons per part 27 rotorcraft and 6.2 gallons per part 29 rotorcraft. Applying fuel prices of $1.87 per gallon for part 27 rotorcraft and $1.78 for part 29 rotorcraft the estimated increase in average annual operating costs is $68 ($1.87 × 3.8 gals. × 9.5 lbs.) per part 27 rotorcraft and $364 ($1.78 × 6.2 gals. × 33 lbs.) per part 29 rotorcraft.

Assuming 15-year operating lives, the total incremental development, certification, production, and operating costs when discounted are $1,426 per part 27 rotorcraft and $4,617 per part 29 rotorcraft.

Benefit/Costs Comparison

Benefits exceed costs for both parts 27 and 29 rotorcraft. The net present value (discounted benefits minus discounted costs) is $1,677 per part 27 rotorcraft and $6,368 per part 29 rotorcraft. The rule will be cost beneficial even if it is only 50 percent effective in eliminating PCF fatalities and injuries.

Regulatory Flexibility Determination

The Regulatory Flexibility Act (RFA) of 1980 was enacted by Congress to ensure that small entities are not unnecessarily or disproportionately burdened by Government regulations. The RFA requires a Regulatory Flexibility Analysis if a rule is expected to have a "significant economic impact on a substantial number of small entities." FAA Order 2100.14A, Regulatory Flexibility Criteria and Guidance, prescribes standards for complying with RFA review requirements in FAA rulemaking actions. The FAA does not expect the rule to have a significant economic impact on a substantial number of small manufacturers or operators.

Trade Impact Assessment

The rule will have no impact on trade for either U.S. firms doing business in foreign markets or foreign firms doing business in the United States. In the United States, foreign manufacturers must meet U.S. requirements, and thus will gain no competitive advantage. In foreign countries, U.S. manufacturers are not bound by parts 27 and 29 requirements and can choose whether or not to implement the provisions of this rule on the basis of competitive and other considerations. Also, the Joint Airworthiness Authority (JAA) and Transport Canada are both in the process of adopting this rule.

Federalism Implications

The regulations herein do not have substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this amendment does not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

Conclusion

For the reasons discussed in the preamble and based on the findings in the Regulatory Flexibility Determination and the Trade Impact Assessment, the FAA has determined that these amendments are not major under Executive Order 12866. In addition, the FAA certifies that these amendments do not have a significant economic impact, positive or negative, on a substantial number of small entities under the criteria of the Regulatory Flexibility Act. These amendments are considered nonsignificant under DOT Regulatory Policies and Procedures (44 FR 11034; February 26, 1979). A regulatory evaluation of the amendments, including a Regulatory Determination and Trade Impact Analysis, has been placed in the docket. A copy may be obtained by contacting the Rules Docket (AGC–10), Docket No. 26392, 800 Independence Avenue, SW., Washington, DC 25890.

The Amendment

Accordingly, the Federal Aviation Administration amends 14 CFR parts 27 and 29 of the Federal Aviation Regulations as effective November 2, 1994.

The authority citation for part 27 continues to read as follows:

Authority: 49 U.S.C. 1344, 1354(a), 1355, 1421, 1423, 1425, 1428, 1429, 1430; and 49 U.S.C. 106(g).

Subpart C—Strength Requirements

General

§ 27.301 Loads.

(a) Strength requirements are specified in terms of limit loads (the maximum loads to be expected in service) and ultimate loads (limit loads multiplied by prescribed factors of safety). Unless otherwise provided, prescribed loads are limit loads.

(b) Unless otherwise provided, the specified air, ground, and water loads must be placed in equilibrium with inertia forces, considering each item of mass in the rotorcraft. These loads must be distributed to closely approximate or conservatively represent actual conditions.

(c) If deflections under load would significantly change the distribution of external or internal loads, this redistribution must be taken into account.

§ 27.303 Factor of safety.

Unless otherwise provided, a factor of safety of 1.5 must be used. This factor applies to external and inertia loads unless its application to the resulting internal stresses is more conservative.

§ 27.305 Strength and deformation.

(a) The structure must be able to support limit loads without detrimental or permanent deformation. At any load up to limit loads, the deformation may not interfere with safe operation.

(b) The structure must be able to support ultimate loads without failure. This must be shown by—

(1) Applying ultimate loads to the structure in a static test for at least three seconds; or

(2) Dynamic tests simulating actual load application.

§ 27.307 Proof of structure.

(a) [Compliance with the strength and deformation requirements of this subpart must be shown for each critical loading condition accounting for the environment to which the structure will be exposed in operation. Structural analysis (static or fatigue) may be used only if the structure conforms to those structures for which experience has shown this method to be reliable. In other cases, substantiating load tests must be made.]

(b) Proof of compliance with the strength requirements of this subpart must include—

(1) Dynamic and endurance tests of rotors, rotor drives, and rotor controls;

(2) Limit load tests of the control system, including control surfaces;

(3) Operation tests of the control system;

(4) Flight stress measurement tests;

(5) Landing gear drop tests; and

(6) Any additional tests required for new or unusual design features.

(Amdt. 27–3, Eff. 10/17/68); (Amdt. 27–26, Eff. 4/5/90)

§ 27.309 Design limitations.

The following values and limitations must be established to show compliance with the structural requirements of this subpart:

(a) The design maximum weight.

(b) The main rotor r.p.m. ranges, power on and power off.

(c) The maximum forward speeds for each main rotor r.p.m. within the ranges determined under paragraph (b) of this section.

(d) The maximum rearward and sideward flight speeds.

(e) The center of gravity limits corresponding to the limitations determined under paragraphs (b), (c), and (d) of this section.

(f) The rotational speed ratios between each powerplant and each connected rotating component.

(g) The positive and negative limit maneuvering load factors.

FLIGHT LOADS

§ 27.321 General.

(a) The flight load factor must be assumed to act normal to the longitudinal axis of the rotorcraft, and to be equal in magnitude and opposite in direction to the rotorcraft inertia load factor at the center of gravity.

(b) Compliance with the flight load requirements of this subpart must be shown—

(1) At each weight from the design minimum weight to the design maximum weight; and

(2) With any practical distribution of disposable load within the operating limitations in the Rotorcraft Flight Manual.

(Amdt. 27–11, Eff. 2/1/77)

§ 27.337 Limit maneuvering load factor.

[The rotorcraft must be designed for—

[(a) A limit maneuvering load factor ranging from a positive limit of 3.5 to a negative limit of −1.0; or

[(b) Any positive limit maneuvering load factor not less than 2.0 and any negative limit maneuvering load factor of not less than −0.5 for which—

[(1) The probability of being exceeded is shown by analysis and flight tests to be extremely remote; and

[(2) The selected values are appropriate to each weight condition between the design maximum and design minimum weights.]

(Amdt. 27–26, Eff. 4/5/90)

§ 27.339 Resultant limit maneuvering loads.

The loads resulting from the application of limit maneuvering load factors are assumed to act at the center of each rotor hub and at each auxiliary lifting surface, and to act in directions, and with distributions of load among the rotors and auxiliary lifting surfaces, so as to represent each critical maneuvering condition, including power-on and power-off flight with the maximum design rotor tip speed ratio. The rotor tip speed ratio is the ratio of the rotorcraft flight velocity component in the plane of the rotor disc to the rotational tip speed of the rotor blades, and is expressed as follows:

$$\mu = \frac{V \cos a}{\Omega R}$$

Where—

V=The airspeed along flight path (f.p.s.);

a=The angle between the projection, in the plane of symmetry, of the axis of no feathering and a line perpendicular to the flight path (radians, positive when the axis is pointing aft);

omega=The angular velocity of rotor (radians per second); and

R=The rotor radius (ft).

(Amdt. 27–11, Eff. 2/1/77)

§ 27.341 Gust loads.

The rotorcraft must be designed to withstand, at each critical airspeed including hovering, the loads resulting from a vertical gust of 30 feet per second.

[§ 27.351 Yawing conditions.

[(a) Each rotorcraft must be designed for the loads resulting from the maneuvers specified in paragraphs (b) and (c) of this section with—

[(1) Unbalanced aerodynamic moments about the center of gravity which the aircraft reacts to in a rational or conservative manner considering the principal masses furnishing the reacting inertia forces; and

[(2) Maximum main rotor speed.

[(b) To produce the load required in paragraph (a) of this section, in unaccelerated flight with zero yaw, at forward speeds from zero up to 0.6 V_{NE}—

[(1) Displace the cockpit directional control suddenly to the maximum deflection limited by the control stops or by the pilot force specified in § 27.395(a);

[(2) Attain a resulting sideslip angle or 90°, whichever is less; and

[(3) Return the directional control suddenly to neutral.

[(c) To produce the load required in paragraph (a) of this section, in unaccelerated flight with zero yaw, at forward speeds from 0.6 V_{NE} up to V_{NE} or V_H, whichever is less—

[(1) Displace the cockpit directional control suddenly to the maximum deflection limited by, the control stops or by the pilot force specified in § 27.395(a);

[(2) Attain a resulting sideslip angle or 15°, whichever is less, at the lesser speed of V_{NE} or V_H;

[(3) Vary the sideslip angles of paragraphs (b)(2) and (c)(2) of this section directly with speed; and

[(4) Return the directional control suddenly to neutral.]

(Amdt. 27–26, Eff. 4/5/90)

§ 27.361 Engine torque.

(a) For turbine engines, the limit torque may not be less than the highest of—

(1) The mean torque for maximum continuous power multiplied by 1.25;

(2) The torque required by § 27.923;

(3) The torque required by § 27.927; or

(4) The torque imposed by sudden engine stoppage due to malfunction or structural failure (such as compressor jamming).

(b) For reciprocating engines, the limit torque may not be less that the mean torque for maximum continuous power multiplied by—

(1) 1.33, for engines with five or more cylinders; and

(2) Two, three, and four, for engines with four, three, and two cylinders, respectively.

(Amdt. 27–23, Eff. 10/3/88)

CONTROL SURFACE AND SYSTEM LOADS

§ 27.391 General.

Each auxiliary rotor, each fixed or movable stabilizing or control surface, and each system operating any flight control must meet the requirements of §§ 27.395, 27.397, 27.399, 27.401, 27.403, 27.411, 27.413, and 27.427.

(Amdt. 27–26, Eff. 4/5/90)

§ 27.395 Control system.

(a) The part of each control system from the pilot's controls to the control stops must be designed to withstand pilot forces of not less than—

(1) The forces specified in § 27.397; or

(2) If the system prevents the pilot from applying the limit pilot forces to the system, the maximum forces that the system allows the pilot to apply, but not less than 0.60 times the forces specified in § 27.397.

(b) Each primary control system, including its supporting structure, must be designed as follows:

(1) The system must withstand loads resulting from the limit pilot forces prescribed in § 27.397.

(2) Notwithstanding paragraph (b)(3) of this section, when power-operated actuator controls or power boost controls are used, the system must also withstand the loads resulting from the force output of each normally energized power device, including any single power boost or actuator system failure.

(3) If the system design or the normal operating loads are such that a part of the system cannot react to the limit pilot forces prescribed in § 27.397, that part of the system must be designed to withstand the maximum loads that can be obtained in normal operation. The minimum design loads must, in any case, provide a rugged system for service use, including consideration of fatigue, jamming, ground gusts, control inertia, and friction loads. In the absence of rational analysis, the design loads resulting from 0.60 of the specified limit pilot forces are acceptable minimum design loads.

(4) If operational loads may be exceeded through jamming, ground gusts, control inertia, or friction, the system must withstand the limit pilot forces specified in § 27.397, without yielding.

(Amdt. 27–26, Eff. 4/5/90)

§ 27.397 Limit pilot forces and torques.

(a) Except as provided in paragraph (b) of this section, the limit pilot forces are as follows:

(1) For foot controls, 130 pounds.

(2) For stick controls, 100 pounds fore and aft, and 67 pounds laterally.

(b) For flap, tab, stabilizer, rotor brake, and landing gear operating controls, the following apply (R=radius in inches):

(1) Crank, wheel, and level controls, [1+R] 3/×50 pounds, but not less than 50 pounds nor more than 100 pounds for hand operated controls or 130 pounds for foot operated controls, applied at any angle within 20 degrees of the plane of motion of the control.

(2) Twist controls, 80R pounds.

(Amdt. 27–11, Eff. 2/1/77)

§ 27.399 Dual control system.

Each dual primary flight control system must be designed to withstand the loads that result when pilot forces of 0.75 times those obtained under § 27.395 are applied—

(a) In opposition; and

(b) In the same direction.

§ 27.401 [Removed].

§ 27.403 [Removed]

§ 27.411 Ground clearance: Tail rotor guard.

(a) It must be impossible for the tail rotor to contact the landing surface during a normal landing.

(b) If a tail rotor guard is required to show compliance with paragraph (a) of this section—

(1) Suitable design loads must be established for the guard; and

(2) The guard and its supporting structure must be designed to withstand those loads.

§ 27.413 [Removed].

§ 27.427 Unsymmetrical loads.

(a) Horizontal tail surfaces and their supporting structure must be designed for unsymmetrical loads arising from yawing and rotor wake effects in combination with prescribed flight conditions.

(b) To meet the design criteria of paragraph (a) of this section, in the absence of more rational data, both of the following must be met:

(1) One hundred percent of the maximum loading from the symmetrical flight conditions acts on the surface on one side of the plane of symmetry, and no loading acts on the other side.

(2) Fifty percent of the maximum loading from the symmetrical flight conditions acts on the surface on each side of the plane of symmetry but in opposite directions.

(c) For empennage arrangements where the horizontal tail surfaces are supported by the vertical tail surfaces, the vertical tail surfaces and supporting structure must be designed for the combined vertical horizontal surface loads resulting from each prescribed flight condition, considered separately. The flight conditions must be selected so the maximum design loads are obtained on each surface. In the absence of more rational data, the unsymmetrical horizontal tail surface loading distributions described in this section must be assumed.

(Amdt. 27–26, Eff. 4/5/90); (Amdt. 27–27, Eff. 10/22/90)

GROUND LOADS

§ 27.471 General.

(a) *Loads and equilibrium.* For limit ground loads—

(1) The limit ground loads obtained in the landing conditions in this part must be considered to be external loads that would occur in the rotorcraft structure if it were acting as a rigid body; and

(2) In each specified landing condition, the external loads must be placed in equilibrium with linear and angular inertia loads in a rational or conservative manner.

(b) *Critical centers of gravity.* The critical centers of gravity within the range for which certification is requested must be selected so that the maximum design loads are obtained in each landing gear element.

§ 27.473 Ground loading conditions and assumptions.

(a) For specified landing conditions, a design maximum weight must be used that is not less than the maximum weight. A rotor lift may be assumed to act through the center of gravity throughout the landing impact. This lift may not exceed two-thirds of the design maximum weight.

(b) Unless otherwise prescribed, for each specified landing condition, the rotorcraft must be designed for a limit load factor of not less than the limit inertia load factor substantiated under § 27.725.

(Amdt. 27–2, Eff. 2/25/68)

§ 27.475 Tires and shock absorbers.

Unless otherwise prescribed, for each specified landing condition, the tires must be assumed to be in their static position and the shock absorbers to be in their most critical position.

§ 27.477 Landing gear arrangement.

Sections 27.235, 27.479 through 27.485, and 27.493 apply to landing gear with two wheels aft, and one or more wheels forward, of the center of gravity.

§ 27.479 Level landing conditions.

(a) *Attitudes.* Under each of the loading conditions prescribed in paragraph (b) of this section, the rotorcraft is assumed to be in each of the following level landing attitudes:

(1) An attitude in which all wheels contact the ground simultaneously.

(2) An attitude in which the aft wheels contact the ground with the forward wheels just clear of the ground.

(b) *Loading conditions.* The rotorcraft must be designed for the following landing loading conditions:

(1) Vertical loads applied under § 27.471.

(2) The loads resulting from a combination of the loads applied under paragraph (b)(1) of this section with drag loads at each wheel of not less than 25 percent of the vertical load at that wheel.

(3) If there are two wheels forward, a distribution of the loads applied to those wheels under paragraphs (b)(1) and (2) of this section in a ratio of 40:60.

(c) *Pitching moments.* Pitching moments are assumed to be resisted by—

(1) in the case of the attitude in paragraph (a)(1) of this section, the forward landing gear; and

(2) in the case of the attitude in paragraph (a)(2) of this section, the angular inertia forces.

§ 27.481 Tail-down landing conditions.

(a) The rotorcraft is assumed to be in the maximum nose-up attitude allowing ground clearance by each part of the rotorcraft.

(b) in this attitude, ground loads are assumed to act perpendicular to the ground.

§ 27.483 One-wheel landing conditions.

For the one-wheel landing condition, the rotorcraft is assumed to be in the level attitude and to contact the ground on one aft wheel. In this attitude—

(a) The vertical load must be the same as that obtained on that side under § 27.479(b)(1); and

(b) The unbalanced external loads must be reacted by rotorcraft inertia.

§ 27.485 Lateral drift landing conditions.

(a) The rotorcraft is assumed to be in the level landing attitude, with—

(1) Side loads combined with one-half of the maximum ground reactions obtained in the level landing conditions of § 27.479(b)(1); and

(2) The loads obtained under paragraph (a)(1) of this section applied—

(i) At the ground contact point; or

(ii) For full-swiveling gear, at the center of the axle.

(b) The rotorcraft must be designed to withstand, at ground contact—

(1) When only the aft wheels contact the ground, side loads of 0.8 times the vertical reaction acting inward on one side, and 0.6 times the vertical reaction acting outward on the other side, all combined with the vertical loads specified in paragraph (a) of this section; and

(2) When all wheels contact the ground simultaneously—

(i) For the aft wheels, the side loads specified in paragraph (b)(1) of this section; and

(ii) For the forward wheels, a side load of 0.8 times the vertical reaction combined with the vertical load specified in paragraph (a) of this section.

§ 27.493 Braked roll conditions.

Under braked roll conditions with the shock absorbers in their static positions—

(a) The limit vertical load must be based on a load factor of at least—

(1) 1.33, for the attitude specified in § 27.479(a)(1); and

(2) 1.0, for the attitude specified in § 27.479(a)(2); and

(b) The structure must be designed to withstand, at the ground contact point of each wheel with brakes, a drag load at least the lesser of—

(1) The vertical load multiplied by a coefficient of friction of 0.8; and

(2) The maximum value based on limiting brake torque.

§ 27.497 Ground loading conditions: Landing gear with tail wheels.

(a) *General.* Rotorcraft with landing gear with two wheels forward, and one wheel aft, of the center of gravity must be designed for loading conditions as prescribed in this section.

(b) *Level landing attitude with only the forward wheels contacting the ground.* In this attitude—

(1) The vertical loads must be applied under §§ 27.471 through 27.475;

(2) The vertical load at each axle must be combined with a drag load at that axle of not less than 25 percent of that vertical load; and

(3) Unbalanced pitching moments are assumed to be resisted by angular inertia forces.

(c) *Level landing attitude with all wheels contacting the ground simultaneously.* In this attitude, the rotorcraft must be designed for landing loading conditions as prescribed in paragraph (b) of this section.

(d) *Maximum nose-up attitude with only the rear wheel contacting the ground.* The attitude for this condition must be the maximum nose-up attitude expected in normal operation, including autorotative landings. In this attitude—

(1) The appropriate ground loads specified in paragraphs (b)(1) and (2) of this section must be determined and applied, using a rational method to account for the moment arm between the rear wheel-ground reaction and the rotorcraft center of gravity; or

(2) The probability of landing with initial contact on the rear wheel must be shown to be extremely remote.

(e) *Level landing attitude with only one forward wheel contacting the ground.* In this attitude, the rotorcraft must be designed for ground loads as specified in paragraphs (b)(1) and (3) of this section.

(f) *Side loads in the level landing attitude.* In the attitudes specified in paragraphs (b) and (c) of this section, the following apply:

(1) The side loads must be combined at each wheel with one-half of the maximum vertical ground reactions obtained for that wheel under paragraphs (b) and (c) of this section. In this condition, the side loads must be—

(i) For the forward wheels, 0.8 times the vertical reaction (on one side) acting inward, and 0.6 times the vertical reaction (on the other side) acting outward; and

(ii) For the rear wheel, 0.8 times the vertical reaction.

(2) The loads specified in paragraph (f)(1) of this section must be applied—

(i) At the ground contact point with the wheel in the trailing position (for non-full swiveling landing gear with a lock, steering device, or shimmy damper to keep the wheel in the trailing position); or

(ii) At the center of the axle (for full swiveling landing gear without a lock, steering device, or shimmy damper).

(g) *Braked roll conditions in the level landing attitude.* In the attitudes specified in paragraphs (b) and (c) of this section, and with the shock absorbers in their static positions, the rotorcraft must be designed for braked roll loads as follows:

(1) The limit vertical load must be based on a limit vertical load factor of not less than—

(i) 1.0, for the attitude specified in paragraph (b) of this section; and

(ii) 1.33, for the attitude specified in paragraph (c) of this section.

(2) For each wheel with brakes, a drag load must be applied, at the ground contact point, of not less than the lesser of—

(i) 0.8 times the vertical load; and

(ii) The maximum based on limiting brake torque.

(h) *Rear wheel turning loads in the static ground attitude.* In the static ground attitude, and with the shock absorbers and tires in their static positions, the rotorcraft must be designed for rear wheel turning loads as follows:

(1) A vertical ground reaction equal to the static load on the rear wheel must be combined with an equal sideload.

(2) The load specified in paragraph (h)(1) of this section must be applied to the rear landing gear—

(i) Through the axle, if there is a swivel (the rear wheel being assumed to be swiveled 90 degrees to the longitudinal axis of the rotorcraft); or

(ii) At the ground contact point, if there is a lock, steering device or shimmy damper (the rear wheel being assumed to be in the trailing position).

(i) *Taxiing condition.* The rotorcraft and its landing gear must be designed for loads that would occur when the rotorcraft is taxied over the roughest ground that may reasonably be expected in normal operation.

§ 27.501 Ground loading conditions: Landing gear with skids.

(a) *General.* Rotorcraft with landing gear with skids must be designed for the loading conditions specified in this section. In showing compliance with this section, the following apply:

(1) The design maximum weight, center of gravity, and load factor must be determined under §§ 27.471 through 27.475.

(2) Structural yielding of elastic spring members under limit loads is acceptable.

(3) Design ultimate loads for elastic spring members need not exceed those obtained in a drop test of the gear with—

(i) A drop height of 1.5 times that specified in § 27.725; and

(ii) An assumed rotor lift of not more than 1.5 times that used in the limit drop tests prescribed in § 27.725.

(4) Compliance with paragraphs (b) through (e) of this section must be shown with—

(i) The gear in its most critically deflected position for the landing condition being considered; and

(ii) The ground reactions rationally distributed along the bottom of the skid tube.

(b) *Vertical reactions in the level landing attitude.* In the level attitude, and with the rotorcraft contacting the ground along the bottom of both skids, the vertical reactions must be applied as prescribed in paragraph (a) of this section.

(c) *Drag reactions in the level landing attitude.* In the level attitude, and with the rotorcraft contacting the ground along the bottom of both skids, the following apply:

(1) The vertical reactions must be combined with horizontal drag reactions of 50 percent of the vertical reaction applied at the ground.

(2) The resultant ground loads must equal the vertical load specified in paragraph (b) of this section.

(d) *Sideloads in the level landing attitude.* In the level attitude, and with the rotorcraft contacting the ground along the bottom of both skids, the following apply:

(1) The vertical ground reaction must be—

(i) Equal to the vertical loads obtained in the condition specified in paragraph (b) of this section; and

(ii) Divided equally among the skids.

(2) The vertical ground reactions must be combined with a horizontal sideload of 25 percent of their value.

(3) [The total sideload must be applied equally between the skids and along the length of the skids.]

(4) The unbalanced moments are assumed to be resisted by angular inertia.

(5) The skid gear must be investigated for—

(i) Inward acting sideloads; and

(ii) Outward acting sideloads.

(e) *One-skid landing loads in the level attitude.* In the level attitude, and with the rotorcraft contacting the ground along the bottom of one skid only, the following apply:

(1) The vertical load on the ground contact side must be the same as that obtained on that side in the condition specified in paragraph (b) of this section.

(2) The unbalanced moments are assumed to be resisted by angular inertia.

(f) *Special conditions.* In addition to the conditions specified in paragraphs (b) and (c) of this section, the rotorcraft must be designed for the following ground reactions:

(1) A ground reaction load acting up and aft at an angle of 45° to the longitudinal axis of the rotorcraft. This load must be—

(i) Equal to 1.33 times the maximum weight;

(ii) Distributed symmetrically among the skids;

(iii) Concentrated at the forward end of the straight part of the skid tube; and

(iv) Applied only to the forward end of the skid tube and its attachment to the rotorcraft.

(2) With the rotorcraft in the level landing attitude, a vertical ground reaction load equal to one-half of the vertical load determined under paragraph (b) of this section. This load must be—

(i) Applied only to the skid tube and its attachment to the rotorcraft; and

(ii) [Distributed equally over 33.3 percent of the length between the skid tube attachments and centrally located midway between the skid tube attachments.]

(Amdt. 27–2, Eff. 2/25/68); (Amdt. 27–26, Eff. 4/5/90)

§ 27.505 Ski landing conditions.

If certification for ski operation is requested, the rotorcraft, with skis, must be designed to withstand the following loading conditions (where P is the maximum static weight on each ski with the rotorcraft at design maximum weight, and n is the limit load factor determined under § 27.473(b).

(a) Up-load conditions in which—

(1) A vertical load of Pn and a horizontal load of $Pn/4$ are simultaneously applied at the pedestal bearings; and

(2) A vertical load of 1.33 P is applied at the pedestal bearings.

(b) A side-load condition in which a side load of 0.35 Pn is applied at the pedestal bearings in a horizontal plane perpendicular to the centerline of the rotorcraft.

(c) A torque-load condition in which a torque load of 1.33 P (in foot pounds) is applied to the ski about the vertical axis through the centerline of the pedestal bearings.

WATER LOADS

§ 27.521 Float landing conditions.

If certification for float operation is requested, the rotorcraft, with floats, must be designed to withstand the following loading conditions (where the limit load factor is determined under § 27.473(b) or assumed to be equal to that determined for wheel landing gear):

(a) Up-load conditions in which—

(1) A load is applied so that, with the rotorcraft in the static level attitude, the resultant water reaction passes vertically through the center of gravity; and

(2) The vertical load prescribed in paragraph (a)(1) of this section is applied simultaneously with an aft component of 0.25 times the vertical component.

(b) A side-load condition in which—

(1) A vertical load of 0.75 times the total vertical load specified in paragraph (a)(1) of this section is divided equally among the floats; and

(2) For each float, the load share determined under paragraph (b)(1) of this section, combined with a total side load of 0.25 times the total vertical load specified in paragraph (b)(1) of this section, is applied to the float only.

MAIN COMPONENT REQUIREMENTS

§ 27.547 Main rotor structure.

(a) Each main rotor assembly (including rotor hubs and blades) must be designed as prescribed in this section.

(b) [Reserved]

(c) The main rotor structure must be designed to withstand the following loads prescribed in §§ 27.337 through 27.341:

(1) Critical flight loads.

(2) Limit loads occurring under normal conditions of autorotation. For this condition, the rotor r.p.m. must be selected to include the effects of altitude.

(d) The main rotor structure must be designed to withstand loads simulating—

(1) For the rotor blades, hubs, and flapping hinges, the impact force of each blade against its stop during ground operation; and

(2) Any other critical condition expected in normal operation.

(e) The main rotor structure must be designed to withstand the limit torque at any rotational speed, including zero. In addition:

(1) The limit torque need not be greater than the torque defined by a torque limiting device (where provided), and may not be less than the greater of—

(i) The maximum torque likely to be transmitted to the rotor structure in either direction; and

(ii) The limit engine torque specified in § 27.361.

(2) The limit torque must be distributed to the rotor blades in a rational manner.

(Amdt. 27–3, Eff. 10/17/68)

§ 27.549 Fuselage, landing gear, and rotor pylon structures.

(a) Each fuselage, landing gear, and rotor pylon structure must be designed as prescribed in this section. Resultant rotor forces may be represented as a single force applied at the rotor hub attachment point.

(b) Each structure must be designed to withstand—

(1) The critical loads prescribed in §§ 27.337 through 27.341;

(2) The applicable ground loads prescribed in §§ 27.235, 27.471 through 27.485, 27.493, 27.497, 27.501, 27.505, and 27.521; and

(3) The loads prescribed in § 27.547(d)(2) and (e).

(c) Auxiliary rotor thrust, and the balancing air and inertia loads occurring under accelerated flight conditions, must be considered.

(d) Each engine mount and adjacent fuselage structure must be designed to withstand the loads occurring under accelerated flight and landing conditions, including engine torque.

(Amdt. 27–3, Eff. 10/17/68)

EMERGENCY LANDING CONDITIONS

§ 27.561 General.

(a)The rotorcraft, although it may be damaged in emergency landing conditions on land or water, must be designed as prescribed in this section to protect the occupants under those conditions.

(b) The structure must be designed to give each occupant every reasonable chance of escaping serious injury in a crash landing when—

(1) Proper use is made of seats, belts, and other safety design provisions;

(2) The wheels are retracted (where applicable); and

(3) Each occupant and each item of mass inside the cabin that could injure an occupant is restrained when subjected to the following ultimate inertial load factors relative to the surrounding structure:

(i) Upward—4g.

(ii) Forward—16g.

(iii) Sideward—8g.

(iv) Downward—20g, after the intended displacement of the seat device.

(c) The supporting structure must be designed to restrain, under any ultimate inertial load up to those specified in this paragraph, any item of mass above and/or behind the crew and passenger compartment that could injure an occupant if it came loose in an emergency landing. Items of mass to be considered include, but are not limited to, rotors, transmissions, and engines. The items of mass must be restrained for the following ultimate inertial load factors:

(1) Upward—1.5*g*.

(2) Forward—8*g*.

(3) Sideward—2*g*.

(4) Downward—4*g*.

[(d) Any fuselage structure in the area of internal fuel tanks below the passenger floor level must be designed to resist the following ultimate inertial factors and loads and to protect the fuel tanks from rupture when those loads are applied to that area:

[(i) Upward—1.5g.

[(ii) Forward—4.0g.

[(iii) Sideward—2.0g.

[(iv) Downward—4.0g.]

(Amdt. 27–3, Eff. 10/17/68); (Amdt. 27–25, Eff. 12/13/89); [(Amdt. 27–30, Eff. 11/2/94)]

[27.562 Emergency landing dynamic conditions.]

[(a) The rotorcraft, although it may be damaged in an emergency crash landing, must be designed to reasonably protect each occupant when—

[(1) The occupant properly uses the seats, safety belts, and shoulder harnesses provided in the design; and

[(2) The occupant is exposed to the loads resulting from the conditions prescribed in this section.

[(b) Each seat type design or other seating device approved for crew or passenger occupancy during takeoff and landing must successfully complete dynamic tests or be demonstrated by rational analysis based on dynamic tests of a similar type seat in accordance with the following criteria. The tests must be conducted with an occupant, simulated by a 170-pound anthropomorphic test dummy (ATD), as defined by 49 CFR 572, subpart B, or its equivalent, sitting in the normal upright position.

[(1) A change in downward velocity of not less than 30 feet per second when the seat or other seating device is oriented in its nominal position with respect to the rotorcraft's reference system, the rotorcraft's longitudinal axis is canted upward 60° with respect to the impact velocity vector, and the rotorcraft's lateral axis is perpendicular to a vertical plane containing the impact velocity vector and the rotorcraft's longitudinal axis. Peak floor deceleration must occur in f thmore than 0.031 seconds after impact and must reach a minimum of 30g's.

[(2) A change in forward velocity of not less than 42 feet per second when the seat or other seating device is oriented in its nominal position with respect to the rotorcraft's reference system, the rotorcraft's longitudinal axis is yawed 10° either right or left of the impact velocity vector (whichever would cause the greatest load on the shoulder harness), the rotorcraft's lateral axis is contained in a horizontal plane containing the impact velocity vector, and the rotorcraft's vertical axis is perpendicular to a horizontal plane containing the impact velocity vector. Peak floor deceleration must occur in not more than 0.071 seconds after impact and must reach a minimum of 18.4g's.

[(3) When floor rails or floor or sidewall attachment devices are used to attach the seating devices to the airframe structure for the conditions of this section, the rails or devices must be misaligned with respect to each other by at least 10° vertically (i.e., pitch out of parallel, and by at least a 10° lateral roll, with the directions optional, to account for possible floor warp.

[(c) Compliance with the following must be shown:

[(1) The seating device system must remain intact although it may experience separation intended as part of its design.

[(2) The attachment between the seating device and the airframe structure must remain intact, although the structure may have exceeded its limit load.

[(3) The ATD's shoulder harness strap or straps must remain on or in the immediate vicinity of the ATD's shoulder during the impact.

[(4) The safety belt must remain on the ATD's pelvis during the impact.

[(5) The ATD's head either does not contact any portion, of the crew or passenger compartment, or if contact is made, the head impact does not exceed a head injury criteria (HIC) of 1,000 as determined by this equation.

$$HIC = (t_2 - t_1)\left[\frac{1}{(t_2 - t_1}\int_{t_1}^{t_2} a(t)dt\right]^{2.5}$$

Where: a(t) is the resultant acceleration at the center of gravity of the head form expressed as a multiple of g (the acceleration of gravity) and $t_2 - t_1$ is the time duration, in seconds, of major head impact, not to exceed 0.05 seconds.

[(6) Loads in individual upper torso harness straps must not exceed 1,750 pounds. If dual straps are used for retaining the upper torso, the total harness strap loads must not exceed 2,000 pounds.]

(7) The maximum compressive load measured between the pelvis and the lumbar column of the ATD must not exceed 1,500 pounds.

(d) An alternate approach that achieves an equivalent or greater level of occupant protection, as required by this section, must be substantiated on a rational basis.

(Amdt. 27–25, Eff. 12/13/89)

§ 27.563 Structural ditching provisions.

[If certification with ditching provisions is requested, structural strength for ditching must meet the requirements of this section and § 27.801(e).

[(a) *Forward speed landing conditions.* The rotorcraft must initially contact the most critical wave for reasonably probable water conditions at forward velocities from zero up to 30 knots in likely pitch, roll, and yaw attitudes. The rotorcraft limit vertical descent velocity may not be less than 5 feet per second relative to the mean water surface. Rotor lift may be used to act through the center of gravity throughout the landing impact. This lift may not exceed two-thirds of the design maximum weight. A maximum forward velocity of less than 30 knots may be used in design if it can be demonstrated that the forward velocity selected would not be exceeded in a normal one-engine-out touchdown.

[(b) *Auxiliary or emergency float conditions.*

[(1) *Floats fixed or deployed before initial water contact.* In addition to the landing loads in paragraph (a) of this section, each auxiliary or emergency float, of its support and attaching structure in the airframe or fuselage, must be designed for the load developed by a fully immersed float unless it can be shown that full immersion is unlikely. If full immersion is unlikely, the highest likely float buoyancy load must be applied. The highest likely buoyancy load must include consideration of a partially immersed float creating restoring moments to compensate the upsetting moments caused by side wind, unsymmetrical rotorcraft loading, water wave action, rotorcraft inertia, and probable structural damage and leakage considered under § 27.801(d). Maximum roll and pitch angles determined from compliance with § 27.801(d) may be used, if significant, to determine the extent of immersion of each float. If the floats are deployed in flight, appropriate air loads derived from the flight limitations with the floats deployed shall be used in substantiation of the floats and their attachment to the rotorcraft. For this purpose, the design airspeed for limit load is the float deployed airspeed operating limit multiplied by 1.11.

[(2) *Floats deployed after initial water contact.* Each float must be designed for full or partial immersion prescribed in paragraph (b)(1) of this section. In addition, each float must be designed for combined vertical and drag loads using a relative limit speed of 20 knots between the rotorcraft and the water. The vertical load may not be less than the highest likely buoyancy load determined under paragraph (b)(1) of this section.]

(Amdt. 27–11, Eff. 2/1/77); (Amdt. 27–26, Eff. 4/5/90)

FATIGUE EVALUATION

§ 27.571 Fatigue evaluation of flight structure.

(a) [*General.* Each portion of the flight structure (the flight structure includes rotors, rotor drive systems between the engines and the rotor hubs, controls, fuselage, landing gear, and their related primary attachments), the failure of which could be catastrophic, must be identified and must be evaluated under paragraph (b), (c), (d) or (e) of this section. The following apply to each fatigue evaluation:]

(1) The procedure for the evaluation must be approved.

(2) The locations of probable failure must be determined.

(3) Inflight measurement must be included in determining the following:

(i) Loads or stresses in all critical conditions throughout the range of limitations in § 27.309, except that maneuvering load factors need not exceed the maximum values expected in operation.

(ii) The effect of altitude upon these loads or stresses.

(4) [The loading spectra must be as severe as those expected in operation including, but not limited to, external cargo operations, if applicable, and ground-air-ground cycles. The loading spectra must be based on loads or stresses determined under paragraph (a)(3) of this section.]

(b) *Fatigue tolerance evaluation.* It must be shown that the fatigue tolerance of the structure ensures that the probability of catastrophic fatigue failure is extremely remote without establishing replacement times, inspection intervals or other procedures under section A27.4 of appendix A.

(c) *Replacement time valuation.* It must be shown that the probability of catastrophic fatigue failure is extremely remote within a replacement time furnished under section A27.4 of appendix A.

(d) *Fail-safe evaluation.* The following apply to fail-safe evaluation:

(1) It must be shown that all partial failures will become readily detectable under inspection procedures furnished under section A27.4 of appendix A.

(2) The interval between the time when any partial failure becomes readily detectable under paragraph (d)(1) of this section, and the time when any such failure is expected to reduce the remaining strength of the structure to limit or maximum attainable loads (whichever is less), must be determined.

(3) It must be shown that the interval determined under paragraph (d)(2) of this section is long enough, in relation to the inspection intervals and related procedures furnished under section A27.4 of appendix A, to provide a probability of detection great enough to ensure that the probability of catastrophic failure is extremely remote.

(e) *Combination of replacement time and failsafe evaluations.* A component may be evaluated under a combination of paragraphs (c) and (d) of this section. For such component it must be shown that the probability of catastrophic failure is extremely remote with an approved combination of replacement time, inspection intervals, and related procedures furnished under section A27.4 of appendix A.

(Amdt. 27–3, Eff. 10/17/68); (Amdt. 27–12, Eff. 5/2/77); (Amdt. 27–18, Eff. 10/14/80); (Amdt. 27–26, Eff. 4/5/90)

Subpart E—Powerplant

GENERAL

§ 27.901 Installation.

(a) For the purpose of this part, the powerplant installation includes each part of the rotorcraft (other than the main and auxiliary rotor structures) that—

(1) Is necessary for propulsion;

(2) Affects the control of the major propulsive units; or

(3) Affects the safety of the major propulsive units between normal inspections or overhauls.

(b) For each powerplant installation—

(1) [Each component of the installation must be constructed, arranged, and installed to ensure its continued safe operation between normal inspections or overhauls for the range of temperature and altitude for which approval is requested;]

(2) Accessibility must be provided to allow any inspection and maintenance necessary for continued airworthiness;

(3) Electrical interconnections must be provided to prevent differences of potential between major components of the installation and the rest of the rotorcraft;

(4) Axial and radial expansion of turbine engines may not affect the safety of the installation; and

[(5) Design precautions must be taken to minimize the possibility of incorrect assembly of components and equipment essential to safe operation of the rotorcraft, except where operation which the incorrect assembly can be shown to be extremely improbable.]

(c) The installation must comply with—

(1) The installation instructions provided under § 33.5 of this chapter; and

(2) The applicable provisions of this subpart.

(Amdt. 27–2, Eff. 2/25/68); (Amdt. 27–12, Eff. 5/2/77); (Amdt. 27–23, Eff. 10/3/88)

§ 27.903 Engines.

(a) *Engine type certification.* [Each engine must have an approved type certificate. Reciprocating engines for use in helicopters must be qualified in accordance with § 33.49(d) of this chapter or be otherwise approved for the intended usage.]

(b) [*Engine or drive system cooling fan blade protection.*]

[(1) If an engine or rotor drive system cooling fan is installed, there must be means to protect the rotorcraft and allow a safe landing if a fan blade fails. This must be shown by showing that—

[(i) The fan blades are contained in case of failure;

[(ii) Each fan is located so that a failure will not jeopardize safety; or

[(iii) Each fan blade can withstand an ultimate load of 1.5 times the centrifugal force resulting from operation limited by the following:

[(A) For fans driven directly by the engine—

[(*1*) The terminal engine r.p.m. under uncontrolled conditions; or

[(*2*) An overspeed limiting device.

[(B) For fans driven by the rotor drive system, the maximum rotor drive system rotational speed to be expected in service, including transients.

[(2) Unless a fatigue evaluation under § 27.571 is conducted, it must be shown that cooling fan blades are not operating at resonant conditions within the operating limits of the rotorcraft.]

(c) *Turbine engine installation.* For turbine engine installations, the powerplant systems associated with engine control devices, systems, and instrumentation must be designed to give reasonable assurance that those engine operating limitations that adversely affect turbine rotor structural integrity will not be exceeded in service.

(Amdt. 27–11, Eff. 2/1/77); (Amdt. 27–20, Eff. 3/26/84); (Amdt. 27–23, Eff. 10/3/88)

§ 27.907 Engine vibration.

(a) Each engine must be installed to prevent the harmful vibration of any part of the engine or rotorcraft.

(b) The addition of the rotor and the rotor drive system to the engine may not subject the principal rotating parts of the engine to excessive vibration stresses. This must be shown by a vibration investigation.

(c) No part of the rotor drive system may be subjected to excessive vibration stresses.

ROTOR DRIVE SYSTEM

§ 27.917 Design.

(a) Each rotor drive system must incorporate a unit for each engine to automatically disengage that engine from the main and auxiliary rotors if that engine fails.

(b) Each rotor drive system must be arranged so that each rotor necessary for control in autorotation will continue to be driven by the main rotors after disengagement of the engine from the main and auxiliary rotors.

(c) If a torque limiting device is used in the rotor drive system, it must be located so as to allow continued control of the rotorcraft when the device is operating.

(d) The rotor drive system includes any part necessary to transmit power from the engines to the rotor hubs. This includes gear boxes, shafting, universal joints, couplings, rotor brake assemblies, clutches, supporting bearings for shafting, any attendant accessory pads or drives, and any cooling fans that are a part of, attached to, or mounted on the rotor drive system.

(Amdt. 27–11, Eff. 2/1/77)

§ 27.921 Rotor brake.

If there is a means to control the rotation of the rotor drive system independently of the engine, any limitations on the use of that means must be specified, and the control for that means must be guarded to prevent inadvertent operation.

§ 27.923 Rotor drive system and control mechanism tests.

(a) Each part tested as prescribed in this section must be in a serviceable condition at the end of the tests. No intervening disassembly which might affect test results may be conducted.

(b) Each rotor drive system and control mechanism must be tested for not less than 100 hours. The test must be conducted on the rotorcraft, and the torque must be absorbed by the rotors to be installed, except that other ground or flight test facilities with other appropriate methods of torque absorption may be used if the conditions of support and vibration closely simulate the conditions that would exist during a test on the rotorcraft.

(c) A 60-hour part of the test prescribed in paragraph (b) of this section must be run at not less than maximum continuous torque and the maximum speed for use with maximum continuous torque. In this test, the main rotor controls must be set in the position that will give maximum longitudinal cyclic pitch change to simulate forward flight. The auxiliary rotor controls must be in the position for normal operation under the conditions of the test.

(d) A 30-hour or, for rotorcraft for which the use of either 30-minute OEI power or continuous OEI power is requested, a 25-hour part of the test prescribed in paragraph (b) of this section must be run at not less than 75 percent of maximum continuous torque and the minimum speed for use with 75 percent of maximum continuous torque. The main and auxiliary rotor controls must be in the position for normal operation under the conditions of the test.

(e) [A 10-hour part of the test prescribed in paragraph (b) of this section must be run at not less than takeoff torque and the maximum speed for use with takeoff torque. The main and auxiliary rotor controls must be in the normal position for vertical ascent.

[(1) For multiengine rotorcraft for which the use of 2 1/2-minute OEI power is requested, 12 runs during the 10-hour test must be conducted as follows:

[(i) Each run must consist of at least one period of 2 1/2 minutes with takeoff torque and the maximum speed for use with takeoff torque on all engines.

[(ii) Each run must consist of at least one period for each engine in sequence, during which that engine simulates a power failure and the remaining engines are run at 2 1/2-minute OEI torque and the maximum speed for use with 2 1/2-minute OEI torque for 2 1/2 minutes.

[(2) For multiengine, turbine-powered rotorcraft for which the use of 30-second and 2-minute OEI power is requested, 10 runs must be conducted as follows:

[(i) Immediately following a takeoff run of at least 5 minutes, each power source must simulate a failure, in turn, and apply the maximum torque and the maximum speed for use with 30-second OEI power to the remaining affected drive system power inputs for not less than 30 seconds, followed by application of the maximum torque and the maximum speed for use with 2-minute OEI power for not less than 2 minutes. At least one run sequence must be conducted from a simulated "flight idle" condition. When conducted on a bench test, the test sequence must be conducted following stabilization at takeoff power.

[(ii) For the purpose of this paragraph, an affected power input includes all parts of the rotor drive system which can be adversely affected by the application of higher or asymmetric torque and speed prescribed by the test.

[(iii) This test may be conducted on a representative bench test facility when engine limitations either preclude repeated use of this power or would result in premature engine removal during the test. The loads, the vibration frequency, and the methods of application to the affected rotor drive system components must be representative of rotorcraft conditions. Test components must be those used to show compliance with the remainder of this section.]

(f) The parts of the test prescribed in paragraphs (c) and (d) of this section must be conducted in intervals of not less than 30 minutes and may be accomplished either on the ground or in flight. The part of the test prescribed in paragraph (e) of this section must be conducted in intervals of not less than 5 minutes.

(g) At intervals of not more than 5 hours during the tests prescribed in paragraphs (c) (d), and (e) of this section, the engine must be stopped rapidly enough to allow the engine and rotor drive to be automatically disengaged from the rotors.

(h) Under the operating conditions specified in paragraph (c) of this section, 500 complete cycles of lateral control, 500 complete cycles of longitudinal control of the main rotors, and 500 complete cycles of control of each auxiliary rotor must be accomplished. A "complete cycle" involves movement of the controls from the neutral position, through both extreme positions, and back to the neutral position, except that control movements need not produce loads or flapping motions exceeding the maximum loads or motions encountered in flight. The cycling may be accomplished during the testing prescribed in paragraph (c) of this section.

(i) At least 200 start-up clutch engagements must be accomplished—

(1) So that the shaft on the driven side of the clutch is accelerated; and

(2) Using a speed and method selected by the applicant.

(j) For multiengine rotorcraft for which the use of 30-minute OEI power is requested, five runs must be made at 30-minute OEI torque and the maximum speed for use with 30-minute OEI torque, in which each engine, in sequence, is made inoperative and the remaining engine(s) is run for a 30-minute period.

(k) For multiengine rotorcraft for which the use of continuous OEI power is requested, five runs must be made at continuous OEI torque and the maximum speed for use with continuous OEI torque, in which each engine, in sequence, is made inoperative and the remaining engine(s) is run for a 1-hour period.

(Amdt. 27–2, Eff. 2/25/68); (Amdt. 27–12, Eff. 5/2/77); (Amdt. 27–23, Eff. 10/3/88); [(Amdt. 27–29, Eff. 10/17/94)]

§ 27.927 Additional tests.

(a) Any additional dynamic, endurance, and operational tests, and vibratory investigations necessary to determine that the rotor drive mechanism is safe, must be performed.

(b) If turbine engine torque output to the transition can exceed the highest engine or transmission torque rating limit, and that output is not directly controlled by the pilot under normal operating conditions (such as where the primary engine power control is accomplished through the flight control), the following test must be made:

(1) Under conditions associated with all engines operating, make 200 applications, for 10 seconds each, of torque that is at least equal to the lesser of—

(i) The maximum torque used in meeting § 27.923 plus 10 percent; or

(ii) The maximum attainable torque output of the engines, assuming that torque limiting devices, if, any, function properly.

(2) For multiengine rotorcraft under conditions associated with each engine, in turn, becoming inoperative, apply to the remaining transmission torque inputs the maximum torque attainable under probable operating conditions, assuming that torque limiting devices, if, any, function properly. Each transmission input must be tested at this maximum torque for at least 15 minutes.

(3) [The tests prescribed in this paragraph must be conducted on the rotorcraft at the maximum rotational speed intended for the power

condition of the test and the torque must be absorbed by the rotors to be installed, except that other ground or flight test facilities with other appropriate methods of torque absorption may be used if the conditions of support and vibration closely simulate the conditions that would exist during a test on the rotorcraft.]

(c) It must be shown by tests that the rotor drive system is capable of operating under autorotative conditions for 15 minutes after the loss of pressure in the rotor drive primary oil system.

(Amdt. 27–2, Eff. 2/25/68); (Amdt. 27–12, Eff. 5/2/77); (Amdt. 27–23, Eff. 10/3/88)

§ 27.931 Shafting critical speed.

(a) The critical speeds of any shafting must be determined by demonstration, except that analytical methods may be used if reliable methods of analysis are available for the particular design.

(b) If any critical speed lies within, or close to, the operating ranges for idling, power on, and autorotative conditions, the stresses occurring at that speed must be within safe limits. This must be shown by tests.

(c) If analytical methods are used and show that no critical speed lies within the permissible operating ranges, the margins between the calculated critical speeds and the limits of the allowable operating ranges must be adequate to allow for possible variations between the computed and actual values.

§ 27.935 Shafting joints.

Each universal joint, slip joint, and other shafting joints whose lubrication is necessary for operation must have provision for lubrication.

§ 27.939 Turbine engine operating characteristics.

(a) Turbine engine operating characteristics must be investigated in flight to determine that no adverse characteristics (such as stall, surge, or flameout) are present, to a hazardous degree, during normal and emergency operation within the range of operating limitations of the rotorcraft and the engine.

(b) The turbine engine air inlet system may not, as a result of airflow distortion during normal operation, cause vibration harmful to the engine.

(c) For governor-controlled engines, it must be shown that there exists no hazardous torsional instability of the drive system associated with critical combinations of power, rotational speed, and control displacement.

(Amdt. 27–1, Eff. 6/4/67); (Amdt. 27–11, Eff. 2/1/77)

FUEL SYSTEM

§ 27.951 General.

(a) Each fuel system must be constructed and arranged to ensure a flow of fuel at a rate and pressure established for proper engine functioning under any likely operating condition, including the maneuvers for which certification is requested.

(b) Each fuel system must be arranged so that—

(1) No fuel pump can draw fuel from more than one tank at a time; or

(2) There are means to prevent introducing air into the system.

(c) Each fuel system for a turbine engine must be capable of sustained operation throughout its flow and pressure range with fuel initially saturated with water at 80°F and having 0.75cc of free water per gallon added and cooled to the most critical condition for icing likely to be encountered in operation.

(Amdt. 27–9, Eff. 10/31/74)

[§ 27.952 Fuel system crash resistance.

[Unless other means acceptable to the Administrator are employed to minimize the hazard of fuel fires to occupants following an otherwise survivable impact (crash landing), the fuel systems must incorporate the design features of this section. These systems must be shown to be capable of sustaining the static and dynamic deceleration loads of this section, considered as ultimate loads acting alone, measured at the system component's center of gravity, without structural damage to system components, fuel tanks, or their attachments that would leak fuel to an ignition source.

(a) *Drop test requirements.* Each tank, or the most critical tank, must be drop-tested as follows:

(1) The drop height must be at least 50 feet.

(2) The drop impact surface must be nondeforming.

(3) The tank must be filled with water to 80 percent of the normal, full capacity.

(4) The tank must be enclosed in a surrounding structure representative of the installation unless it can be established that the surrounding structure is free of projections or other design features likely to contribute to rupture of the tank.

(5) The tank must drop freely and impact in a horizontal position ±10°.

(6) After the drop test, there must be no leakage.

(b) *Fuel Tank Load Factors.* Except for fuel tanks located so that tank rupture with fuel release to either significant ignition sources, such as engines, heaters, and auxiliary power units, or occupants is extremely remote, each fuel tank must be designed and installed to retain its contents under the following ultimate inertial load factors, acting alone.

(1) For fuel tanks in the cabin:

(i) Upward—4g.

(ii) Forward—16g.

(iii) Sideward—8g.

(iv) Downward—20g.

(2) For fuel tanks located above or behind the crew or passenger compartment that, if loosened, could injure an occupant in an emergency landing:

(i) Upward—1.5g.

(ii) Forward—8g.

(iii) Sideward—2g.

(iv) Downward - 4g.

(3) For fuel tanks in other areas:

(i) Upward - 1.5g.

(ii) Forward - 4g.

(iii) Sideward - 2g.

(iv) Downward - 4g.

(c) *Fuel line self-sealing breakaway couplings.* Self-sealing breakaway couplings must be installed unless hazardous relative motion of fuel system components to each other or to local rotorcraft structure is demonstrated to be extremely improbable or unless other means are provided. The couplings or equivalent devices must be installed at all fuel tank-to-fuel line connections, tank-to-tank interconnects, and at other points in the fuel system where local structural deformation could lead to the release of fuel.

(1) The design and construction of self-sealing breakaway couplings must incorporate the following design features:

(i) The load necessary to separate a breakaway coupling must be between 25 to 50 percent of the minimum ultimate failure load (ultimate strength) of the weakest component in the fluid-carrying line. The separation load must in no case be less than 300 pounds, regardless of the size of the fluid line.

(ii) A breakaway coupling must separate whenever its ultimate load (as defined in paragraph (c)(1)(i) of this section) is applied in the failure modes most likely to occur.

(iii) All breakaway couplings must incorporate design provisions to visually ascertain that the coupling is locked together (leak-free) and is open during normal installation and service.

(iv) All breakaway couplings must incorporate design provisions to prevent uncoupling or unintended closing due to operational shocks, vibrations, or accelerations.

(v) No breakaway coupling design may allow the release of fuel once the coupling has performed its intended function.

(2) All individual breakaway couplings, coupling fuel feed systems, or equivalent means must be designed, tested, installed, and maintained so that inadvertent fuel shutoff in flight is improbable in accordance with § 27.955(a) and must comply with the fatigue evaluation requirements of § 27.571 without leaking.

(3) Alternate, equivalent means to the use of breakaway couplings must not create a survivable impact-induced load on the fuel line to which it is installed greater than 25 to 50 percent of the ultimate load (strength) of the weakest component in the line and must comply with the fatigue requirements of § 27.571 without leaking.

(d) *Frangible or deformable structural attachments.* Unless hazardous relative motion of fuel tanks and fuel system components to local rotorcraft structure is demonstrated to be extremely improbable in an otherwise survivable impact, frangible or locally deformable attachments of fuel tanks and fuel system components to local rotorcraft structure must be used. The attachment of fuel tanks and fuel system components to local rotorcraft structure, whether frangible or locally deformable, must be designed such that its separation or relative local deformation will occur without rupture or local tear-out of the fuel tank or fuel system components that will cause fuel leakage. The ultimate strength of frangible or deformable attachments must be as follows:

(1) The load required to separate a frangible attachment from its support structure, or deform a locally deformable attachment relative to its support structure, must be between 25 and 50 percent of the minimum ultimate load (ultimate strength) of the weakest component in the attached system. In no case may the load be less than 300 pounds.

(2) A frangible or locally deformable attachment must separate or locally deform as intended

whenever its ultimate load (as defined in paragraph (d)(1) of this section) is applied in the modes most likely to occur.

(3) All frangible or locally deformable attachments must comply with the fatigue requirements of § 27.571.

(e) *Separation of fuel and ignition sources.* To provide maximum crash resistance, fuel must be located as far as practicable from all occupiable areas and from all potential ignition sources.

(f) *Other basic mechanical design criteria.* Fuel tanks, fuel lines, electrical wires, and electrical devices must be designed, constructed, and installed, as far as practicable, to be crash resistant.

(g) *Rigid or Semirigid fuel tanks.* Rigid or semirigid fuel tank or bladder walls must be impact and tear resistant.]

[(Amdt. 27–30, Eff. 11/2/94)]

§ 27.953 Fuel system independence.

(a) Each fuel system for multiengine rotorcraft must allow fuel to be supplied to each engine through a system independent of those parts of each system supplying fuel to other engines. However, separate fuel tanks need not be provided for each engine.

(b) If a single fuel tank is used on a multiengine rotorcraft, the following must be provided:

(1) Independent tank outlets for each engine, each incorporating a shutoff valve at the tank. This shutoff valve may also serve as the firewall shutoff valve required by § 27.995 if the line between the valve and the engine compartment does not contain a hazardous amount of fuel that can drain into the engine compartment.

(2) At least two vents arranged to minimize the probability of both vents becoming obstructed simultaneously.

(3) Filler caps designed to minimize the probability of incorrect installation or inflight loss.

(4) A fuel system in which those parts of the system from each tank outlet to any engine are independent of each part of each system supplying fuel to other engines.

27.954 Fuel system lightning protection.

The fuel system must be designed and arranged to prevent the ignition of fuel vapor within the system by—

(a) Direct lightning strikes to areas having a high probability of stroke attachment;

(b) Swept lightning strokes to areas where swept strokes are highly probable; or

(c) Corona and streamering at fuel vent outlets.

(Amdt. 27–23, Eff. 10/3/88)

§ 27.955 Fuel flow.

(a) *General.* The fuel system for each engine must be shown to provide the engine with at least 100 percent of the fuel required under each operating and maneuvering condition to be approved for the rotorcraft including, as applicable, the fuel required to operate the engine(s) under the test conditions required by § 27.927. Unless equivalent methods are used, compliance must be shown by test during which the following provisions are met except that combinations of conditions which are shown to be improbable need not be considered.

(1) The fuel pressure, corrected for critical accelerations, must be within the limits specified by the engine type certificate data sheet.

(2) The fuel level in the tank may not exceed that established as unusable fuel supply for the tank under § 27.959, plus the minimum additional fuel necessary to conduct the test.

(3) The fuel head between the tank outlet and the engine inlet must be critical with respect to rotorcraft flight attitudes.

(4) The critical fuel pump (for pump-fed systems) is installed to produce (by actual or simulated failure) the critical restriction to fuel flow to be expected from pump failure.

(5) Critical values of engine rotation speed, electrical power, or other sources of fuel pump motive power must be applied.

(6) Critical values of fuel properties which adversely affect fuel flow must be applied.

(7) The fuel filter required by § 27.997 must be blocked to the degree necessary to simulate the accumulation of fuel contamination required to activate the indicator required by § 27.1305(q).

(b) *Fuel transfer systems.* If normal operation of the fuel system requires fuel to be transferred to an engine feed tank, the transfer must occur automatically via a system which has been shown to maintain the fuel level in the engine feed tank within acceptable limits during flight or surface operation of the rotorcraft.

(c) *Multiple fuel tanks.* If an engine can be supplied with fuel from more than one tank, the fuel systems must, in addition to having appropriate manual switching capability, be designed to prevent interruption of fuel flow to that engine, without attention by the flightcrew, when any tank supply fuel to that engine is depleted of usable fuel during normal operation, and any other tank that normally supplies fuel to the engine alone contains usable fuel.

(Amdt. 27–1, Eff. 6/4/67); (Amdt. 27–23, Eff. 10/3/88)

§ 27.959 Unusable fuel supply.

The unusable fuel supply for each tank must be established as not less than the quantity at which the first evidence of malfunction occurs under the most adverse fuel feed condition occurring under any intended operations and flight maneuvers involving that tank.

§ 27.961 Fuel system hot weather operation.

Each suction lift fuel system and other fuel systems with features conducive to vapor formation must be shown by test to operate satisfactorily (within certification limits) when using fuel at a temperature of 110° F under critical operating conditions including, if applicable, the engine operating conditions defined by § 27.927(b)(1) and (b)(2).

(Amdt. 27–23, Eff. 10/3/88)

§ 27.963 Fuel tanks: General.

(a) Each fuel tank must be able to withstand, without failure, the vibration, inertia, fluid, and structural loads to which it may be subjected in operation.

(b) Each fuel tank of 10 gallons or greater capacity must have internal baffles, or must have external support to resist surging.

(c) Each fuel tank must be separated from the engine compartment by a firewall. At least one-half inch of clear airspace must be provided between the tank and the firewall.

(d) Spaces adjacent to the surfaces of fuel tanks must be ventilated so that fumes cannot accumulate in the tank compartment in case of leakage. If two or more tanks have interconnected outlets, they must be considered as one tank, and the airspaces in those tanks must be interconnected to prevent the flow of fuel from one tank to another as a result of a difference in pressure between those airspaces.

(e) The maximum exposed surface temperature of any component in the fuel tank must be less, by a safe margin as determined by the Administrator, than the lowest expected autoignition temperature of the fuel or fuel vapor in the tank. Compliance with this requirement must be shown under all operating conditions and under all failure or malfunction conditions of all components inside the tank.

(f) [Each fuel tank installed in personnel compartments must be isolated by fume-proof and fuel-proof enclosures that are drained and vented to the exterior of the rotorcraft. The design and construction of the enclosures must provide necessary protection for the tank, must be crash resistant during a survivable impact in accordance with § 27.952, and must be adequate to withstand loads and abrasions to be expected in personnel compartments.

[(g) Each flexible fuel tank bladder or liner must be approved or shown to be suitable for the particular application and must be puncture resistant. Puncture resistance must be shown by meeting the TSO–C80, paragraph 16.0, requirments using a minimum puncture force of 370 pounds.

[(h) Each integral fuel tank must have provisions for inspection and repair of its interior.]

(Amdt. 27–23, Eff. 10/3/88); [(Amdt. 27–30, Eff. 11/2/94)]

§ 27.965 Fuel tank tests.

(a) Each fuel tank must be able to withstand the applicable pressure tests in this section without failure or leakage. If practicable, test pressures may be applied in a manner simulating the pressure distribution in service.

(b) Each conventional metal tank, nonmetallic tank with walls that are not supported by the rotorcraft structure, and integral tank must be subjected to a pressure of 3.5 p.s.i. unless the pressure developed during maximum limit acceleration or emergency deceleration with a full tank exceeds this value, in which case a hydrostatic head, or equivalent test, must be applied to duplicate the acceleration loads as far as possible. However, the pressure need not exceed 3.5 p.s.i. on surfaces not exposed to the acceleration loading.

(c) Each nonmetallic tank with walls supported by the rotorcraft structure must be subjected to the following tests:

(1) A pressure test of at least 2.0 p.s.i. This test may be conducted on the tank alone in conjunction with the test specified in paragraph (c)(2) of this section.

(2) A pressure test, with the tank mounted in the rotorcraft structure, equal to the load developed by the reaction of the contents, with the tank full, during maximum limit acceleration or emergency deceleration. However, the pressure need not exceed 2.0 p.s.i. on surfaces not exposed to the acceleration loading.

(d) Each tank with large unsupported or unstiffened flat areas, or with other features whose failure or deformation could cause leakage, must be subjected to the following test or its equivalent:

(1) Each complete tank assembly and its support must be vibration tested while mounted to simulate the actual installation.

(2) The tank assembly must be vibrated for 25 hours while two-thirds full of any suitable fluid. The amplitude of vibration may not be less than one thirty-second of an inch, unless otherwise substantiated.

(3) The test frequency of vibration must be as follows:

(i) If no frequency of vibration resulting from any r.p.m. within the normal operating range of engine or rotor system speeds is critical, the test frequency of vibration, in number of cycles per minute must, unless a frequency based on a more rational calculation is used, be the number obtained by averaging the maximum and minimum power-on engine speeds (r.p.m.) for reciprocating engine powered rotorcraft or 2,000 c.p.m. for turbine engine powered rotorcraft.

(ii) If only one frequency of vibration resulting from any r.p.m. within the normal operating range of engine or rotor system speeds is critical, that frequency of vibration must be the test frequency.

(iii) If more than one frequency of vibration resulting from any r.p.m. within the normal operating range of engine or rotor system speeds is critical, the most critical of these frequencies must be the test frequency.

(4) Under paragraphs (d)(3)(ii) and (iii) of this section, the time of test must be adjusted to accomplish the same number of vibration cycles as would be accomplished in 25 hours at the frequency specified in paragraph (d)(3)(i) of this section.

(5) During the test, the tank assembly must be rocked at the rate of 16 to 20 complete cycles per minute through an angle of 15 degrees on both sides of the horizontal (30 degrees total), about the most critical axis, for 25 hours). If motion about more than one axis is likely to be critical, the tank must be rocked about each critical axis for 12½ hours.

(Amdt. 27–12, Eff. 5/2/77)

[§ 27.967 Fuel tank installation.

[(a) Each fuel tank must be supported so that tank loads are not concentrated on unsupported tank surfaces. In addition—

(1) There must be pads, if necessary, to prevent chafing between each tank and its supports;

(2) The padding must be nonabsorbent or treated to prevent the absorption of fuel;

(3) If flexible tank liners are used, they must be supported so that it is not necessary for them to withstand fluid loads; and

(4) Each interior surface of tank compartments must be smooth and free of projections that could cause wear of the liner unless—

(i) There are means for protection of the liner at those points; or

(ii) The construction of the liner itself provides such protection.

(b) Any spaces adjacent to tank surfaces must be adequately ventilated to avoid accumulation of fuel or fumes in those spaces due to minor leakage. If the tank is in a sealed compartment, ventilation may be limited to drain holes that prevent clogging and excessive pressure resulting from altitude changes. If flexible tank liners are installed, the venting arrangement for the spaces between the liner and its container must maintain the proper relationship to tank vent pressures for any expected flight condition.

(c) The location of each tank must meet the requirements of § 27.1185(a) and (c).

(d) No rotorcraft skin immediately adjacent to a major air outlet from the engine compartment may act as the wall of the integral tank.]

[(Amdt. 27–30, Eff. 11/2/94)]

§ 27.969 Fuel tank expansion space.

Each fuel tank or each group of fuel tanks with interconnected vent systems must have an expansion space of not less than 2 percent of the tank capacity). It must be impossible to fill the fuel tank expansion space inadvertently with the rotorcraft in the normal ground attitude.

(Amdt. 27–23, Eff. 10/3/88)

§ 27.971 Fuel tank sump.

(a) Each fuel tank must have a drainable sump with an effective capacity in any ground attitude to be expected in service of 0.25 percent of the tank capacity or one sixteenth gallon, whichever is greater, unless—

(1) The fuel system has a sediment bowl or chamber that is accessible for preflight drainage and has a minimum capacity of 1 ounce for every 20 gallons of fuel tank capacity; and

(2) Each fuel tank drain is located so that in any ground attitude to be expected in service, water will drain from all parts of the tank to the sediment bowl or chamber.

(b) Each sump, sediment bowl, and sediment chamber drain required by the section must comply with the drain provisions of § 27.999(b).

(Amdt. 27–23, Eff. 10/3/88)

§ 27.973 Fuel tank filler connection.

[(a) Each fuel tank filler connection must prevent the entrance of fuel into any part of the rotorcraft other than the tank itself during normal operations and must be crash resistant during a survivable impact in accordance with § 27.952(c). In addition—

(1) Each filler must be marked as prescribed in § 27.1557(c)(1);

(2) Each recessed filler connection that can retain any appreciable quantity of fuel must have a drain that discharges clear of the entire rotorcraft; and

(3) Each filler cap must provide a fuel-tight seal under the fluid pressure expected in normal operation and in a survivable impact.

(b) Each filler cap or filler cap cover must warn when the cap is not fully locked or seated on the filler connection.]

[(Amdt. 27–30, Eff. 11/2/94)]

§ 27.975 Fuel tank vents.

(a) Each fuel tank must be vented from the top part of the expansion space so that venting is effective under all normal flight conditions. Each vent must minimize the probability of stoppage by dirt or ice.

(b) [The venting system must be designed to minimize spillage of fuel through the vents to an ignition source in the event of a rollover during landing, ground operation, or a survivable impact, unless a rollover is shown to be extremely remote.]

(Amdt. 27–23, Eff. 10/3/88); [(Amdt. 27–30, Eff. 11/2/94)]

§ 27.977 Fuel tank outlet.

(a) There must be a fuel strainer for the fuel tank outlet or for the booster pump. This strainer must—

(1) For reciprocating engine powered rotorcraft, have 8 to 16 meshes per inch; and

(2) For turbine engine powered rotorcraft, prevent the passage of any object that could restrict fuel flow or damage any fuel system component.

(b) The clear area of each fuel tank outlet strainer must be at least five times the area of the outlet line.

(c) The diameter of each strainer must be at least that of the fuel tank outlet.

(d) Each finger strainer must be accessible for inspection and cleaning.

(Amdt. 27–11, Eff. 2/1/77)

FUEL SYSTEM COMPONENTS

§ 27.991 Fuel pumps.

Compliance with § 27.955 may not be jeopardized by failure of—

(a) Any one pump except pumps that are approved and installed as parts of a type certificated engine; or

(b) Any component required for pump operation except, for engine driven pumps, the engine served by that pump.

(Amdt. 27–2, Eff. 2/25/68); (Amdt. 27–23, Eff. 10/3/88)

§ 27.993 Fuel system lines and fittings.

(a) Each fuel line must be installed and supported to prevent excessive vibration and to withstand loads due to fuel pressure and accelerated flight conditions.

(b) Each fuel line connected to components of the rotorcraft between which relative motion could exist must have provisions for flexibility.

(c) Flexible hose must be approved.

(d) Each flexible connection in fuel lines that may be under pressure or subjected to axial loading must use flexible hose assemblies.

(e) No flexible hose that might be adversely affected by high temperatures may be used where excessive temperatures will exist during operation or after engine shutdown.

(Amdt. 27–2, Eff. 2/25/68)

§ 27.995 Fuel valves.

(a) There must be a positive, quick-acting valve to shut off fuel to each engine individually.

(b) The control for this valve must be within easy reach of appropriate crewmembers.

(c) Where there is more than one source of fuel supply there must be means for independent feeding from each source.

(d) No shutoff valve may be on the engine side of any firewall.

§ 27.997 Fuel strainer or filter.

There must be a fuel strainer or filter between the fuel tank outlet and the inlet of the first fuel system component which is susceptible to fuel contamination, including but not limited to the fuel metering device or an engine positive displacement pump, whichever is nearer the fuel tank outlet. This fuel strainer or filter must—

(a) Be accessible for draining and cleaning and must incorporate a screen or element which is easily removable;

(b) Have a sediment trap and drain except that it need not have a drain if the strainer or filter is easily removable for drain purposes;

(c) Be mounted so that its weight is not supported by the connecting lines or by the inlet or outlet connections of the strainer or filter itself, unless adequate strength margins under all loading conditions are provided in the lines and connections; and

(d) Provide a means to remove from the fuel any contaminant which would jeopardize the flow of fuel through rotorcraft or engine fuel system components required for proper rotorcraft fuel system or engine fuel system operation.

(Amdt. 27–9, Eff. 10/31/74); (Amdt. 27–20, Eff. 3/26/84); (Amdt. 27–23, Eff. 10/3/88)

§ 27.999 Fuel system drains.

(a) There must be at least one accessible drain at the lowest point in each fuel system to completely drain the system with the rotorcraft in any ground attitude to be expected in service.

(b) Each drain required by paragraph (a) of this section must—

(1) Discharge clear of all parts of the rotorcraft:

(2) Have manual or automatic means to assure positive closure in the off position; and

(3) Have a drain valve—

(i) That is readily accessible and which can be easily opened and closed; and

(ii) That is either located or protected to prevent fuel spillage in the event of a landing with landing gear retracted.

(Amdt. 27–11, Eff. 2/1/77); (Amdt. 27–23, Eff. 10/3/88)

OIL SYSTEM

§ 27.1011 Engines: General.

(a) Each engine must have an independent oil system that can supply it with an appropriate quantity of oil at a temperature not above that safe for continuous operation.

(b) The usable oil capacity of each system may not be less than the product of the endurance of the rotorcraft under critical operating conditions and the maximum oil consumption of the engine under the same conditions, plus a suitable margin to ensure adequate circulation and cooling. Instead of a rational analysis of endurance and consumption, a usable oil capacity of 1 gallon for each 40 gallons of usable fuel may be used.

(c) The oil cooling provisions for each engine must be able to maintain the oil inlet temperature to that engine at or below the maximum established value. This must be shown by flight tests.

(Amdt. 27–23, Eff. 10/3/88)

§ 27.1013 Oil tanks.

Each oil tank must be designed and installed so that—

(a) It can withstand, without failure, each vibration, inertia, fluid, and structural load expected in operation;

(b) [Reserved]

(c) Where used with a reciprocating engine, it has an expansion space of not less than the greater of 10 percent of the tank capacity or 0.5 gallon, and where used with a turbine engine, it has an expansion space of not less than 10 percent of the tank capacity.

(d) It is impossible to fill the tank expansion space inadvertently with the rotorcraft in the normal ground attitude;

(e) Adequate venting is provided; and

(f) There are means in the filler opening to prevent oil overflow from entering the oil tank compartment.

(Amdt. 27–9, Eff. 10/31/74)

§ 27.1015 Oil tank tests.

Each oil tank must be designed and installed so that it can withstand, without leakage, an internal pressure of 5 p.s.i., except that each pressurized oil tank used with a turbine engine must be designed and installed so that it can withstand, without leakage, an internal pressure of 5 p.s.i., plus the maximum operating pressure of the tank.

(Amdt. 27–9, Eff. 10/31/74)

§ 27.1017 Oil lines and fittings.

(a) Each oil line must be supported to prevent excessive vibration.

(b) Each oil line connected to components of the rotorcraft between which relative motion could exist must have provisions for flexibility.

(c) Flexible hose must be approved.

(d) Each oil line must have an inside diameter of not less than the inside diameter of the engine inlet or outlet. No line may have splices between connections.

§ 27.1019 Oil strainer or filter.

(a) Each turbine engine installation must incorporate an oil strainer or filter through which all of the engine oil flows and which meets the following requirements:

(1) Each oil strainer or filter that has a bypass must be constructed and installed so that oil will flow at the normal rate through the rest of the system with the strainer or filter completely blocked.

(2) The oil strainer or filter must have the capacity (with respect to operating limitations established for the engine) to ensure that engine oil system functioning is not impaired when the oil is contaminated to a degree (with respect to particle size and density) that is greater than that established for the engine under part 33 of this chapter.

(3) The oil strainer or filter, unless it is installed at an oil tank outlet, must incorporate a means to indicate contamination before it reaches the capacity established in accordance with paragraph (a)(2) of this section.

(4) The bypass of a strainer or filter must be constructed and installed so that the release of collected contaminants is minimized by appropriate location of the bypass to ensure that collected contaminants are not in the bypass flow path.

(5) An oil strainer or filter that has no bypass, except one that is installed at an oil tank outlet, must have a means to connect it to the warning system required in § 27.1305(r).

(b) Each oil strainer or filter in a powerplant installation using reciprocating engines must be constructed and installed so that oil will flow at the normal rate through the rest of the system with the strainer or filter element completely blocked.

(Amdt. 27–9, Eff. 10/31/74); (Amdt. 27–20, Eff. 3/26/84); (Amdt. 27–23, Eff. 10/3/88)

§ 27.1021 Oil system drains.

A drain (or drains) must be provided to allow safe drainage of the oil system. Each drain must—

(a) Be accessible; and

(b) Have manual or automatic means for positive locking in the closed position.

(Amdt. 27–20, Eff. 3/26/84)

[§ 27.1027 Transmissions and gearboxes: General.]

[(a) Pressure lubrication systems for transmissions and gearboxes must comply with the engine oil system requirements of §§ 27.1013 (except paragraph (c)), 27.1015, 27.1017, 27.1021, and 27.1337(d).

[(b) Each pressure lubrication system must have an oil strainer or filter through which all of the lubricant flows and must—

[(1) Be designed to remove from the lubricant any contaminant which may damage transmission and drive system components or impede the flow of lubricant to a hazardous degree;

[(2) Be equipped with a means to indicate collection of contaminants on the filter or strainer at or before opening of the bypass required by paragraph (b)(3) of this section; and

[(3) Be equipped with a bypass constructed and installed so that—

[(i) The lubricant will flow at the normal rate through the rest of the system with the strainer of filter completely blocked; and

[(ii) The release of collected contaminants is minimized by appropriate location of the bypass to ensure that collected contaminants are not in the bypass flowpath.

[(c) For each lubricant tank or sump outlet supplying lubrication to rotor drive systems and rotor drive system components, a screen must be provided to prevent entrance into the lubrication system of any object that might obstruct the flow of lubricant from the outlet to the filter required by paragraph (b) of this section. The requirements of paragraph (b) do not apply to screens installed at lubricant tank of sump outlets.

[(d) Splash-type lubrication systems for rotor drive system gearboxes must comply with §§ 27.1021 and 27.1337(d).]

(Amdt. 27–23, Eff. 10/3/88)

COOLING

§ 27.1041 General.

(a) Each powerplant cooling system must be able to maintain the temperatures of powerplant components within the limits established for these components under critical surface (ground or water) and flight operating conditions for which certification is required and after normal shutdown. Powerplant components to be considered include but may not be limited to engines, rotor drive system components, auxiliary power units, and the cooling or lubricating fluids used with these components.

(b) Compliance with paragraph (a) of this section must be shown in tests conducted under the conditions prescribed in that paragraph.

(Amdt. 27–2, Eff. 2/25/68); (Amdt. 27–23, Eff. 10/3/88)

§ 27.1043 Cooling tests.

(a) *General.* For the tests prescribed in § 27.1041(b), the following apply:

(1) If the tests are conducted under conditions deviating from the maximum ambient atmospheric temperature specified in paragraph (b) of this section, the recorded powerplant temperatures must be corrected under paragraphs (c) and (d) of this section unless a more rational correction method is applicable.

(2) No corrected temperature determined under paragraph (a)(1) of this section may exceed established limits.

(3) For reciprocating engines, the fuel used during the cooling tests must be of the minimum grade approved for the engines, and the mixture settings must be those normally used in the flight stages for which the cooling tests are conducted.

(4) The test procedures must be as prescribed in § 27.1045.

(b) *Maximum ambient atmospheric temperature.* A maximum ambient atmospheric temperature corresponding to sea level conditions of at least 100 degrees F must be established. The assumed temperature lapse rate is 3.6 degrees F per thousand feet of altitude above sea level until a temperature of −69.7 degrees F is reached, above which altitude the temperature is considered constant at −69.7 degrees F. However, for winterization installations, the applicant may select a maximum ambient atmospheric temperature corresponding to sea level conditions of less than 100 degrees F.

(c) *Correction factor (except cylinder barrels).* Unless a more rational correction applies, temperatures of engine fluids and power-plant components (except cylinder barrels) for which temperature limits are established, must be corrected by adding to them the difference between the maximum ambient atmospheric temperature and the temperature of the ambient air at the time of the first occurrence of the maximum component or fluid temperature recorded during the cooling test.

(d) *Correction factor for cylinder barrel temperatures.* Cylinder barrel temperatures must be corrected by adding to them 0.7 times the difference between the maximum ambient atmospheric temperature and the temperature of the ambient air at the time of the first occurrence of the maximum cylinder barrel temperature recorded during the cooling test.

(Amdt. 27–11, Eff. 2/1/77); (Amdt. 27–14, Eff. 3/1/78)

§ 27.1045 Cooling test procedures.

(a) *General.* For each stage of flight, the cooling tests must be conducted with the rotorcraft

(1) In the configuration most critical for cooling; and

(2) Under the conditions most critical for cooling.

(b) *Temperature stabilization.* For the purpose of the cooling tests, a temperature is "stabilized" when its rate of change is less than 20° F. per minute. The following component and engine fluid temperature stabilization rules apply:

(1) For each rotorcraft, and for each stage of flight—

(i) The temperatures must be stabilized under the conditions from which entry is made into the stage of flight being investigated; or

(ii) if the entry condition normally does not allow temperatures to stabilize, operation through the fuel entry condition must be conducted before entry into the stage of flight being investigated in order to allow the temperatures to attain their natural levels at the time of entry.

(2) For each helicopter during the takeoff stage of flight, the climb at takeoff power must be preceded by a period of hover during which the temperatures are stabilized.

(c) *Duration of test.* For each stage of flight the tests must be continued until—

(1) [The temperatures stabilize or 5 minutes after the occurrence of the highest temperature recorded, as appropriate to the test condition;]

(2) That stage of flight is completed; or

(3) An operating limitation is reached.

(Amdt. 27–23, Eff. 10/3/88)

INDUCTION SYSTEM

§ 27.1091 Air induction.

(a) The air induction system for each engine must supply the air required by that engine under the operating conditions and maneuvers for which certification is requested.

(b) Each cold air induction system opening must be outside the cowling if backfire flames can emerge.

(c) If fuel can accumulate in any air induction system, that system must have drains that discharge fuel—

(1) Clear of the rotorcraft; and

(2) Out of the path of exhaust flames.

[(d)] For turbine engine powered rotorcraft—

(1)There must be means to prevent hazardous quantities of fuel leakage or overflow from drain, vents, or other components of flammable fluid systems from entering the engine intake system; and

(2) The air inlet ducts must be located or protected so as to minimize the ingestion of foreign matter during takeoff, landing, and taxiing.

(Amdt. 27–2, Eff. 2/25/68); (Amdt. 27–23, Eff. 10/3/88)

§ 27.1093 Induction system icing protection.

(a) *Reciprocating engines.* Each reciprocating engine air induction system must have means to prevent and eliminate icing. Unless this is done by other means, it must be shown that, in air free of visible moisture at a temperature of 300 F., and with the engines at 75 percent of maximum continuous power—

(1) Each rotorcraft with sea level engines using conventional venturi carburetors has a preheater that can provide a heat rise of 90° F.;

(2) Each rotorcraft with sea level engines using carburetors tending to prevent icing has a sheltered alternate source of air, and that the preheat supplied to the alternate air intake is not less than that provided by the engine cooling air downstream of the cylinders;

(3) Each rotorcraft with altitude engines using conventional venturi carburetors has a preheater capable of providing a heat rise of 120° F.; and

(4) Each rotorcraft with altitude engines using carburetors tending to prevent icing has a preheater that can provide a heat rise of—

(i) 100° F.; or

(ii) If a fluid deicing system is used, at least 40° F.

(b) *Turbine engines.*

(1) [It must be shown that each turbine engine and its air inlet system can operate throughout the flight power range of the engine (including idling)—

[(i) Without accumulating ice on engine or inlet system components that would adversely affect engine operation or cause a serious loss of power under the icing conditions specified in appendix C of part 29 of this chapter; and

[(ii) In snow, both falling and blowing, without adverse effect on engine operation, within the limitations established for the rotorcraft.]

(2) Each turbine engine must idle for 30 minutes on the ground, with the air bleed available for engine icing protection at its critical condition, without adverse effect, in an atmosphere that is at a temperature between 15° and 30° F (between −9° and −1° C) and has a liquid water content not less than 0.3 grams per cubic meter in the form of drops having a mean effective diameter of not less than 20 microns, followed by momentary operation at takeoff power or thrust. During the 30 minutes of idle operation, the engine may be run up periodically to a moderate power or thrust setting in a manner acceptable to the Administrator.

(c) *Supercharged reciprocating engines.* For each engine having superchargers to pressurize the air before it enters the carburetor, the heat rise in the air caused by that supercharging at any altitude may be utilized in determining compliance with paragraph (a) of this section if the heat rise utilized is that which will be available, automatically, for the applicable altitude and operating condition because of supercharging.

(Amdt. 27–9, Eff. 10/31/74); (Amdt. 27–11, Eff. 2/1/77); (Amdt. 27–12, Eff. 5/2/77); (Amdt. 27–20, Eff. 3/26/84); (Amdt. 27–23, Eff. 10/3/88)

EXHAUST SYSTEM

§ 27.1121 General.

For each exhaust system—

(a)There must be means for thermal expansion of manifolds and pipes;

(b) There must be means to prevent local hot spots;

(c) Exhaust gases must discharge clear of the engine air intake, fuel system components, and drains;

(d) Each exhaust system part with a surface hot enough to ignite flammable fluids or vapors must be located or shielded so that leakage from any system carrying flammable fluids or vapors will not result in a fire caused by impingement of the fluids or vapors on any part of the exhaust system including shields for the exhaust system.

(e) Exhaust gases may not impair pilot vision at night due to glare; and

(f) If significant traps exist, each turbine engine exhaust system must have drains discharging clear of the rotorcraft, in any normal ground and flight attitudes, to prevent fuel accumulation after the failure of an attempted engine start.

(g) Each exhaust heat exchanger must incorporate means to prevent blockage of the exhaust port after any internal heat exchanger failure.

(Amdt. 27–12, Eff. 5/2/77)

§ 27.1123 Exhaust piping.

(a) Exhaust piping must be heat and corrosion resistant, and must have provisions to prevent failure due to expansion by operating temperatures.

(b) Exhaust piping must be supported to withstand any vibration and inertia loads to which it would be subjected in operations.

(c) Exhaust piping connected to components between which relative motion could exist must have provisions for flexibility.

(Amdt. 27–11, Eff. 2/1/77)

POWERPLANT CONTROLS AND ACCESSORIES

§ 27.1141 Powerplant controls: General.

(a) Powerplant controls must be located and arranged under § 27.777 and marked under § 27.1555.

(b) Each flexible powerplant control must be approved.

(c) Controls of powerplant valves required for safety must have—

(1) For manual valves, positive stops or in the case of fuel valves suitable index provisions, in the open and closed position; and

(2) For power-assisted valves, a means to indicate to the flight crew when the valve—

(i)Is in the fully open or fully closed position; or

(ii) is moving between the fully open and fully closed position.

(d) For turbine engine powered rotorcraft, no single failure or malfunction, or probable combination thereof, in any powerplant control system may cause the failure of any powerplant function necessary for safety.

(Amdt. 27–12, Eff. 5/2/77); (Amdt. 27–23, Eff. 10/3/88)

§ 27.1143 Engine controls.

(a) There must be a separate power control for each engine.

(b) Power controls must be grouped and arranged to allow—

(1) Separate control of each engine; and

(2) Simultaneous control of all engines.

(c) Each power control must provide a positive and immediately responsive means of controlling its engine.

(d) If a power control incorporates a fuel shutoff feature, the control must have a means to prevent the inadvertent movement of the control into the shutoff position. The means must—

(1) Have a positive lock or stop at the idle position; and

(2) Require a separate and distinct operation to place the control in the shutoff position.

[(e) For rotorcraft to be certificated for a 30-second OEI power rating, a means must be provided to automatically activate and control the 30-second OEI power and prevent any engine from exceeding the installed engine limits associated with the 30-second OEI power rating approved for the rotorcraft.]

(Amdt. 27–11, Eff. 2/1/77); (Amdt. 27–23, Eff. 10/3/88); [(Amdt. 27–29, Eff. 10/17/94)]

§ 27.1145 Ignition switches.

(a) There must be a means to quickly shut off all ignition by the grouping of switches or by a master ignition control.

(b) Each group of ignition switches, except ignition switches for turbine engines for which continuous ignition is not required, and each master ignition control must have a means to prevent its inadvertent operation.

(Amdt. 27–12, Eff. 5/2/77)

§ 27.1147 Mixture controls.

If there are mixture controls, each engine must have a separate control and the controls must be arranged to allow—

(a) Separate control of each engine; and

(b)Simultaneous control of all engines.

§ 27.1163 Powerplant accessories.

(a) Each engine-mounted accessory must—

(1) Be approved for mounting on the engine involved;

(2) Use the provisions on the engine for mounting; and

(3) Be sealed in such a way as to prevent contamination of the engine oil system and the accessory system.

(b) Unless other means are provided, torque limiting means must be provided for accessory drives located on any component of the transmission and rotor drive system to prevent damage to these components from excessive accessory load.

(Amdt. 27–2, Eff. 2/25/68); (Amdt. 27–20, Eff. 3/26/84); (Amdt. 27–23, Eff. 10/3/88)

POWERPLANT FIRE PROTECTION

§ 27.1183 Lines, fittings, and components.

(a) Except as provided in paragraph (b) of this section, each line, fitting, and other component carrying flammable fluid in any area subject to engine fire conditions must be fire resistant, except that flammable fluid tanks and supports which are part of and attached to the engine must be fireproof or be enclosed by a fireproof shield unless damage by fire to any non-fireproof part will not cause leakage or spillage of flammable fluid. Components must be shielded or located so as to safeguard against the ignition of leaking flammable fluid. An integral oil sump of less than 25-quart capacity on a reciprocating engine need not be fireproof nor be enclosed by a fireproof shield.

(b) Paragraph (a) does not apply to—

(1) Lines, fittings, and components which are already approved as part of a type certificated engine; and

(2) Vent and drain lines, and their fittings, whose failure will not result in, or add to, a fire hazard.

(c) Each flammable fluid drain and vent must discharge clear of the induction system air inlet.

(Amdt. 27–1, Eff. 6/4/67); (Amdt. 27–9, Eff. 10/31/74); (Amdt. 27–20, Eff. 3/26/84)

§ 27.1185 Flammable fluids.

(a) Each fuel tank must be isolated from the engines by a firewall or shroud.

(b) Each tank or reservoir, other than a fuel tank, that is part of a system containing flammable fluids or gases must be isolated from the engine by a firewall or shroud, unless the design of the system, the materials used in the tank and its supports, the shutoff means, and the connections, lines and controls provide a degree of safety equal to that which would exist if the tank or reservoir were isolated from the engines.

(c) There must be at least one-half inch of clear airspace between each tank and each firewall or shroud isolating that tank, unless equivalent means are used to prevent heat transfer from each engine compartment to the flammable fluid.

(Amdt. 27–2, Eff. 2/25/68); (Amdt. 27–11, Eff. 2/1/77)

§ 27.1187 Ventilation.

Each compartment containing any part of the powerplant installation must have provision for ventilation.

§ 27.1189 Shutoff means.

(a) There must be means to shut off each line carrying flammable fluids into the engine compartment, except—

(1) Lines, fittings, and components forming an integral part of an engine;

(2) For oil systems for which all components of the system, including oil tanks, are fireproof or located in areas not subject to engine fire conditions; and

(3) For reciprocating engine installations only, engine oil system lines in installations using engines of less than 500 cu. in. displacement.

(b) There must be means to guard against inadvertent operation of each shutoff, and to make it possible for the crew to reopen it in flight after it has been closed.

(c) Each shutoff valve and its control must be designed, located, and protected to function properly under any condition likely to result from an engine fire.

(Amdt. 27–2, Eff. 2/25/68); (Amdt. 27–20, Eff. 3/26/84); (Amdt. 27–23, Eff. 10/3/88)

§ 27.1191 Firewalls.

(a) Each engine, including the combustor, turbine, and tailpipe sections of turbine engines must be isolated by a firewall, shroud, or equivalent means, from personnel compartments, structures, controls, rotor mechanisms, and other parts that are—

(1) Essential to a controlled landing; and

(2) Not protected under § 27.861.

(b) Each auxiliary power unit and combustion heater, and any other combustion equipment to be used in flight, must be isolated from the rest of the rotorcraft by firewalls, shrouds, or equivalent means.

(c) In meeting paragraphs (a) and (b) of this section, account must be taken of the probable path of a fire as affected by the airflow in normal flight and in autorotation.

(d) Each firewall and shroud must be constructed so that no hazardous quantity of air, fluids, or flame can pass from any engine compartment to other parts of the rotorcraft.

(e) Each opening in the firewall or shroud must be sealed with close-fitting, fireproof grommets, bushings, or firewall fittings.

(f) Each firewall and shroud must be fireproof and protected against corrosion.

(Amdt. 27–2, Eff. 2/25/68)

§ 27.1193 Cowling and engine compartment covering.

(a) Each cowling and engine compartment covering must be constructed and supported so that it can resist the vibration, inertia, and air loads to which it may be subjected in operation.

(b) There must be means for rapid and complete drainage of each part of the cowling or engine compartment in the normal ground and flight attitudes.

(c) No drain may discharge where it might cause a fire hazard.

(d) Each cowling and engine compartment covering must be at least fire resistant.

(e) Each part of the cowling or engine compartment covering subject to high temperatures due to its nearness to exhaust system parts or exhaust gas impingement must be fireproof.

(f) A means of retaining each openable or readily removable panel, cowling, or engine or rotor drive system covering must be provided to preclude hazardous damage to rotors or critical control components in the event of structural or mechanical failure of the normal retention means, unless such failure is extremely improbable.

(Amdt. 27–23, Eff. 10/3/88)

§ 27.1194 Other surfaces.

All surfaces aft of, and near, powerplant compartments, other than tail surfaces not subject to heat, flames, or sparks emanating from a powerplant compartment, must be at least fire resistant.

(Amdt. 27–2, Eff. 2/25/68)

§ 27.1195 Fire detector systems.

Each turbine engine powered rotorcraft must have approved quick-acting fire detectors in numbers and locations insuring prompt detection of fire in the engine compartment which cannot be readily observed in flight by the pilot in the cockpit.

(Amdt. 27–5, Eff. 4/23/71)

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